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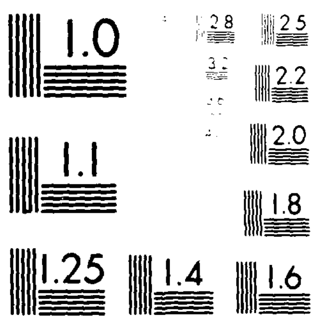
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E-TR-50

MINERAL RESOURCES SURVEY
SEVEN ADDITIONAL VALLEYS
NEVADA/UTAH SITING AREA

VOLUME I

Prepared for:

U. S. Department of the Air Force
Ballistic Missile Office
Norton Air Force Base, California 92409

Prepared by:

Ertec Western, Inc.
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Long Beach, California 90807

23 June 1981

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Results of the evaluation of the mineral- and energy-resource potential of seven MX valleys in Nevada shows that besides the existing mining activities which occur in many mining districts in this area, a large portion of the area is also interpreted to possess high, good, and speculative potential for new economics discoveries to the year 2000 and beyond.

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FOREWORD

This report is a supplement to the regional Mineral Resources Survey for Nevada/Utah (Report No. FN-TR-41) prepared for the Department of the Air Force, Ballistic Missile Office (BMO), in compliance with Contract No. F04704-80-C-0006, CDRL Item 004A2. It contains an evaluation of the mineral and energy resource potential of the seven additional valleys which were added to the MX Designated Deployment Area adjoining the western and northwestern boundary. This report presents the geological, geophysical, and past and present mining activity data upon which the evaluation is based. The scope of the study is guided by the regulations for land withdrawal contained in the Federal Land Policy and Management Act of 1976.

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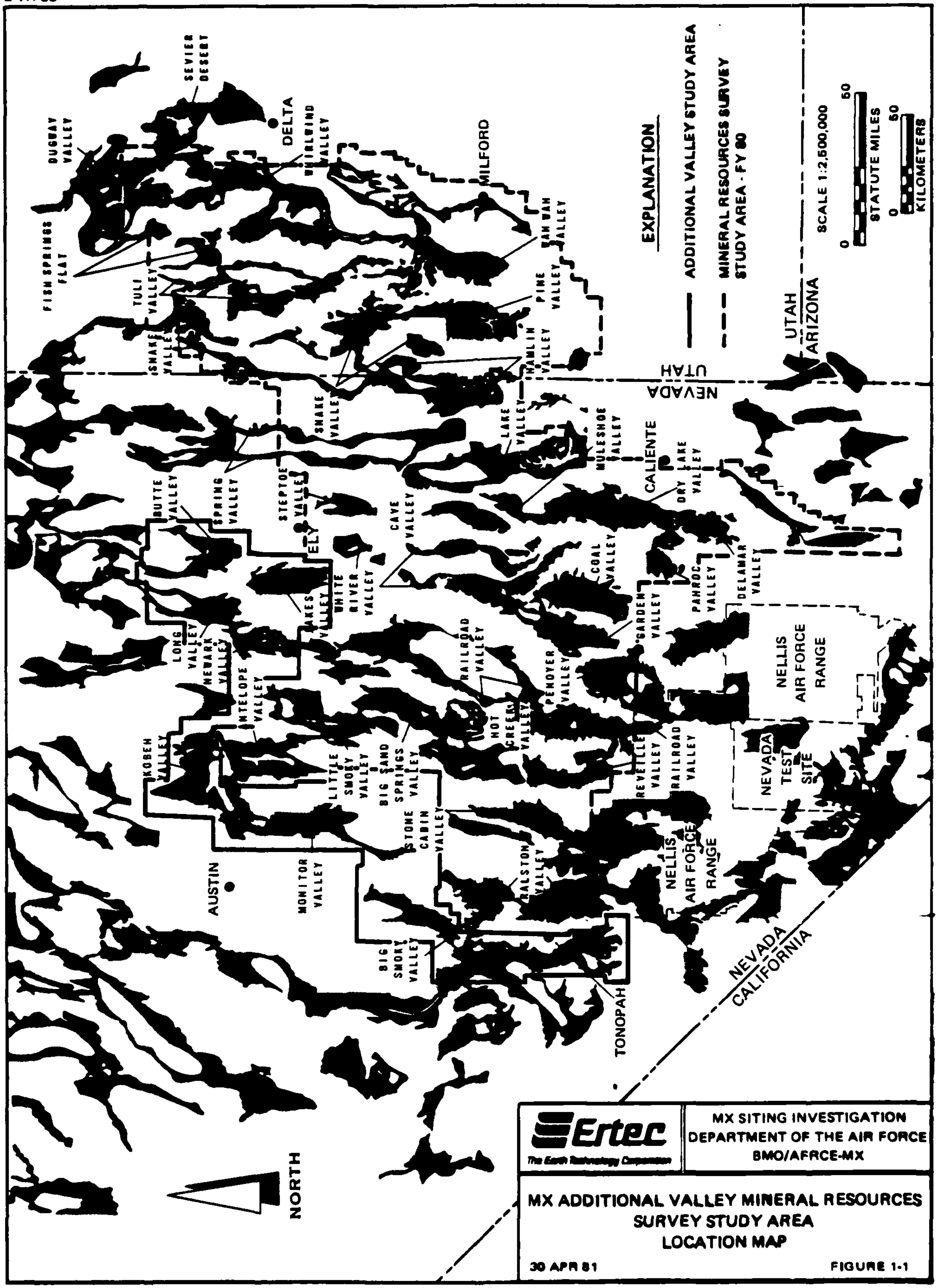
1.0 INTRODUCTION

In November 1980, Ertec Western, Inc. (formerly Fugro National, Inc.) was tasked to perform a supplemental mineral resources survey of seven valleys located in the north and west portions of the MX Designated Deployment Area in Nevada and Utah (Figure 1-1). The seven valleys surveyed were Big Smoky (including Montezuma Valley), Monitor, Kobeh, Jakes, Newark, Long, and Butte. This survey supplements the regional Mineral Resource Survey (report FN-TR-41) for the Nevada/Utah siting area which was completed in October 1980. The supplemental survey was necessary due to the addition of these seven valleys to the MX deployment area after commencement of the regional survey.

Both the regional and supplemental surveys were performed to develop information on mineral and energy resources and their potential for occurrence. The scope of the surveys was designed to meet the requirements for land withdrawal as outlined in the Federal Land Policy and Management Act of 1976 (FLPMA). A description of the work scope is contained in the Regional Mineral Resources Survey (Report No. FN-TR-41) as is a discussion of the mineral survey requirements of FLPMA.

This survey draws heavily on existing published and unpublished data such as geologic and structural data; mine and mining district reports; aeromagnetic, seismic, and gravimetric data; and an inventory of all claims and leases. These data are supplemented by contact with mining companies and individuals with interests in the area, field examination of major active


EXPLANATION
ADDITIONAL VALLEY STUDY AREA
MINERAL RESOURCES SURVEY STUDY AREA - FY 80
SCALE 1:2,500,000
0 50 STATUTE MILES
0 50 KILOMETERS
UTAH
ARIZONA
NEVADA
UTAH
NEVADA
CALIFORNIA
NORTH
SEVIER DESERT
DELTA
DUGWAY VALLEY
WHIRLWIND VALLEY
MILFORD
FISH SPRINGS FLAT
TULE VALLEY
WAH WAH VALLEY
PINE VALLEY
HAMLIN VALLEY
SNAKE VALLEY
LAKE VALLEY
MULESHOE VALLEY
CALIENTE
DRY LAKE VALLEY
BUTTE VALLEY
SPRING VALLEY
STEPTOE VALLEY
ELY
CAVE VALLEY
WHITE RIVER VALLEY
JAKES VALLEY
COAL VALLEY
PAHROC VALLEY
DELAMAR VALLEY
GARDEN VALLEY
RAILROAD VALLEY
LONG VALLEY
NEWARK VALLEY
ANTELOPE VALLEY
PENOYER VALLEY
HOT CREEK VALLEY
NELLIS AIR FORCE RANGE
KOBEH VALLEY
LITTLE SMOKY VALLEY
BIG SAND SPRINGS VALLEY
REVEILLE VALLEY
NEVADA TEST SITE
STONE CABIN VALLEY
RALSTON VALLEY
AUSTIN
MONITOR VALLEY
BIG SMOKY VALLEY
TONOPAH
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DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX
MX ADDITIONAL VALLEY MINERAL RESOURCES
SURVEY STUDY AREA
LOCATION MAP
30 APR 81
FIGURE 1-1

mining operations, and consultation with experts knowledgeable of present and future resource potential in the area. Evaluation of the mineral and energy resources of the MX study area provides a framework by which to assess the resource potential in the MX deployment areas. (For these surveys, the MX deployment areas are synonymous with the suitable valley areas as defined on 20 June 1980.)

This report is divided into the following sections:

- o Conclusions - describes the known and potential mineral and energy resource areas; identifies areas for consideration of high, good, speculative, or low potential; and defines the impacts of the MX system on future mineral exploitation;
- o Study Methodology - describes the methodology used in the survey;
- o Previous studies - sets the framework of past mineral reports and studies in the Nevada and Utah study area;
- o Results - describes the general geologic setting of the siting area and describes in detail the known deposits, production history, environment of occurrence, exploration activity, and potential of the mineral commodities and energy resources; and
- o Land status - describes the present claims and leases in the deployment areas.

This survey represents the combined technical effort of Ertec Western and a group of subcontractor specialists and mineral resources experts. Ertec Western managed the study and coordinated the technical work effort. Ertec Rocky Mountain (formerly Fugro Rocky Mountain) was responsible for the assessment of mineral- and energy-resource potential and for the evaluation of impacts of the MX system on future mineral- and energy-resource development in the area. Warren Woodward, in conjunction with AIM, Inc., was responsible for the inventory of claim and lease information.

2.0 CONCLUSIONS

Evaluation of the mineral- and energy-resource potential of the MX Additional Valley Mineral Resource Survey Study Area concluded that besides the existing mining activities which occur in many mining districts in this area, a large portion of the area is also interpreted to possess high, good, and speculative potential for new economic discoveries to the year 2000 and beyond.

The favorable potential classifications used in this report are described in Section 2.2 and outlined in the drawings that accompany the report.

Exploration and development activity is increasing which reflects the expanding demand for mineral and energy resources. Technological advances in exploration techniques and conventional and unconventional mining and metallurgical recovery methods facilitate these increasing activities.

Virtually all of the past metal mineral discoveries have been in the mountain ranges. It can be predicted, however, that many of the future discoveries for some commodities will be made in the valley areas, especially beneath the thin colluvial cover adjacent to known or suspected mineralized areas. Exploration will then continue working further away from the mountains into areas of thicker alluvial cover until the main valley or basin fault line is reached. At that point, valley bedrock may become too deep for economic mineral recovery.

The explorationist's knowledge of the geologic setting of mineral occurrences, including oil, gas, and geothermal, in the study area and surrounding environs is continually expanding and evolving. As new data become available and a better understanding of mineral occurrences and geologic setting is developed, these data and interpretations will be applied to the search for new deposits. Exploration, like technology, is an evolutionary process requiring adequate time to show results. At least five to 10 years of exploration may be required before the potential of even a small intensely explored area is reasonably well-known. For example, the complex geologic setting of the Overthrust Belt with its oil and gas potential will require years of industry exploration before many of its mineral resources become evident.

The value of specific commodities to society is an important consideration that may change within a short time period. Recent increases in the use of molybdenum, beryllium, lithium, and particularly in a number of the industrial minerals, some of which occur in significant deposits within the study area, are examples. Growing demands for mineral commodities in the decades ahead seem certain to place increased emphasis on exploration and development.

There are 19 metals that the United States imports more than 50 percent of its needs for use by both the private and defense sectors. Some of these metals occur and have been produced within the study area as a principal, co-, or by-product commodity. Gold, zinc, mercury, and tungsten are examples.

2.1 MINERAL- AND ENERGY-RESOURCE OCCURRENCES

The MX Additional Valley Study Area includes the Montezuma Valley (part of southern Big Smoky Valley), Big Smoky Valley, Monitor Valley, Kobeh Valley, Jakes Valley, and part of Newark, Long, and Butte valleys on the northern and western sides of the MX Mineral Resources Survey Study Area (FN-TR-41). All of the western portion of the study area falls within the highly mineralized Antler Orogenic Belt which itself is crossed by several regional lineaments and the very productive Manhattan Mineral Belt. Approximately half of the northern portion of the study area lies within the Eureka Mineral Belt which includes all of the major production centers in the northern portion of the study area except the Cherry Creek District.

Both the western and northern portions of the study area are the sites of current mining operations and intense exploration. Oil and gas exploration is continuing in White Pine County in the northeast portion of the study area, and some oil shale potential may exist in Eureka County in the extreme northwestern portion. Future development of new gold, molybdenum, tungsten, silver, lead, zinc, turquoise, barite, and possibly copper and other industrial mineral resources in the study area is a certainty. The degree to which these resources are developed will depend on the availability of land, human resources, water resources, and ancillary resources necessary for mineral development.

2.2 POTENTIAL MINERAL RESOURCE AREAS

In addition to the districts and deposits presently known and exploited, inferred ore deposit environments are present within the study area based on geologic analogies with adjacent areas. Continuing exploration to the year 2000 and beyond is expected to result in discoveries of new economic deposits of metallics (precious, base, and ferrous metals), uranium, nonmetallics, industrial minerals, and oil and gas in both the ranges and valleys.

The types of potential resource environments and areas identified from the review of the mineral resources of the study area are as follows:

- Deeper zones beneath known developed deposits in many of the identified districts;
- Peripheral areas to identified districts based on geologic inferences;
- Areas outside of identified districts at intersections of favorable geologic structures either within or outside the interpreted mineral belts;
- Areas of favorable sedimentary lithofacies in conjunction with favorable structural setting and presence of indicator metals within ranges (in search of Carlin-type stratiform gold);
- Projections of identified districts and deposits based on geological inferences into adjacent valleys beyond range fronts beneath thin (<2000 feet [600 m]) pediment alluvial cover;
- Buried Paleozoic, Mesozoic, and Tertiary sediments underlying valley-fill alluvial deposits offer good to high potential for oil and gas occurrences throughout much of the study area because of the existence of favorable source and host rocks and the favorable degree of maturation of organic remains in the source rock; and

- Valley sediments from the range fronts to the playa lake areas offer an environment for occurrence within the MX deployment areas of a number of commodities including uranium, beryllium, precious metals, placer, various brines and evaporites (lithium, boron, gypsum-anydrite, and salt), clays, and zeolites.

The potential assigned to various areas for each of the commodities reviewed (precious, base, and ferrous metals, uranium, beryllium, nonmetallic and industrial minerals, geothermal, and oil and gas) are discussed in the text of this report and illustrated in the drawings accompanying the report. A compilation of mineral and energy potential within MX deployment areas evaluated in this report is shown in Drawings 1 and 2. A summary regarding percentage of mineral and energy potential area to total area is presented in Table 2-1.

To estimate the interpreted degree of potential or favorability, a classification system with four categories (high, good, speculative, and low) has been used instead of the U.S. Geological Survey and U.S. Bureau of Mines classification system. In our opinion, the USGS classification system (U. S. Geological Survey, 1976) does not allow enough flexibility for interpretation of geologic parameters to project mineral potential into the future and is designed to classify mineral resources as of a given date. For more information regarding comparison between two systems, refer to Section 2.2 of the Regional Mineral Resources Study (FN-TR-41).

POTENTIAL	AREA (PERCENT MX DEPLOYMENT AREA) [1]		
	MINERAL	ENERGY	
		OIL AND GAS	GEOTHERMAL
HIGH	3	19	
GOOD	8	14	
SPECULATIVE	60	25	
LOW	29	42	
			2*
TOTAL	100	100	

* PERCENT FAVORABLE FOR LOW TO INTERMEDIATE TEMPERATURE GEOTHERMAL RESOURCES.

(1) FOR THIS STUDY MX DEPLOYMENT AREA EQUIVALENT TO GEOTECHNICALLY SUITABLE VALLEY AREA

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SUMMARY OF MINERAL- AND ENERGY-POTENTIAL AREAS

30 APR 81

TABLE 2-1

2.3 SUPPLY-DEMAND IMPLICATION FOR MINERAL COMMODITIES

Mineral resource commodities known or likely to occur within the study area reflect various levels of domestic availability. Only four metallic and nonmetallic commodities currently on the list of strategic commodities are known to occur within the study area. In terms of net importance to the United States, more than 50 percent of these four strategic mineral commodities are currently derived from foreign countries. These commodities are:

- mercury;
- zinc;
- tungsten; and
- gold.

Estimates of the future supply and demand for these and other commodities, described in Section 6.0 of the Regional Mineral Survey (FN-TR-41), suggest that new deposits will have to be discovered particularly if the U.S. is to decrease its reliance on foreign sources. Portions of the study area offer significant potential for discovery of such deposits.

2.4 IMPACT OF THE MX SYSTEM ON MINERAL INDUSTRY

The general and overall impact of MX construction and deployment is discussed in Section 2.4 of the Regional Mineral Survey (FN-TR-41). Specific conflicts between mining and MX in the study area are discussed in this section. Specific areas of possible direct conflict for land use include portions of the townships as follows:

T2S, R42E	Goldfield area placer potential in south Montezuma Valley;

T1N, R42E	Falcon Exploration's future mill site in Montezuma Valley;
T5-6N, R41-42E	Anaconda's Hall Molybdenum Mine and waste disposal area as constructed and with potential future expansion into Big Smoky Valley;
T8N, R43E	Leerco's proposed gold placer operations in Big Smoky Valley west of Manhattan;
T10N, R43-44E	Smoky Valley Mining Company's Round Mountain Gold Mine with near-term mill and waste disposal expansion in Big Smoky Valley; and
T12N, R46E	All Minerals' barite mill and mill site claims in Monitor Valley. Cyprus Mines also has mill site claims covering ± 1 square mile (mi^2) (0.38 square kilometers [km^2]) adjacent to the All Minerals' claims.

The impact on mining of MX deployment in the conflict areas would depend on the stage of development or operation that a given mine was. Impact could range from subtle relocation of some facilities to closing of a mine or indefinite postponement of development. Current access in the study area is shown on Drawing 3.

A major concern of many of the mining companies is water availability during MX construction. In Big Smoky Valley, the Anaconda mill will require as much as 20,000 gallons per minute (gpm) at full production, and pumping rates of less than 10,000 gpm have produced measurable fluctuations in the Big Smoky Valley deep aquifers from which they are pumping (Anaconda Company, personal communication, 1980). The proposed new mill at Round Mountain would also need 10,000 to 20,000 gpm of water from the Big Smoky Valley, and operations at Manhattan will draw

about 5000 gpm from Manhattan Gulch, a feeder to the Big Smoky Valley. The Falcon Exploration mill in Montezuma Valley will also draw water from the Big Smoky Valley ground-water system, and the effect of other major users on this valley's ground water is not known. Similar concerns have been voiced by prospective operators in Kobeh, Newark, Jakes, and Butte valleys.

Another potential impact on mining, specifically on Anaconda's mine in Big Smoky Valley, would be interruption of power to the mill. A 230 kv power line is currently being constructed from Austin, Nevada, to the Hall Mine via Big Smoky Valley. Once the mill is operating, any interruption of this power supply would cause costly shutdown of the mill since an alternate power supply is not available (Anaconda Company, personal communication, 1980).

Some negative impacts of MX deployment on mining in the study area are unavoidable, but careful planning in water use and actual shelter site locations could greatly reduce the long-term effects of MX on the mining industry. Summarizing the impacts of the MX system in the Additional Valley Study Area, the following points should be considered.

If the MX system is deployed in the study area, the severity of impact on the mineral industry will depend upon the extent of deployment and location of shelter sites. A major impact on the mining industry will result if draw-down of the water table occurs in Big Smoky Valley through water appropriation to MX and in other valleys of the study area where existing or future

mill facilities would be affected. Areas with good mineral potential are currently being explored (and in some cases, drilled), and development of mineral discoveries in these areas could be impaired or prevented by MX deployment. Deployment in speculative- and low-potential areas will have few long-term adverse effects on the mineral industry provided that access across the siting areas is maintained and the availability of siting areas for future exploration is guaranteed. Specific areas where siting in speculative- or low-potential areas may conflict with mineral development are already listed in previous pages.

The Air Force has developed a mineral policy for the siting, construction, and operation of the MX missile system in Nevada/ Utah.[1] This policy contains the following elements:

a. Avoidance: The Air Force is committed to not siting components of the MX system on active mining claims or in areas of "High Potential Minerals" as defined in the Mineral Survey for the Great Basin deployment region.

b. Relocation of Facilities: This deals with the Air Force's willingness to move facilities or buy out interests for future mineral discoveries. When future incompatible proposed uses are identified, as a part of the case-by-case decisions, the Air Force will determine whether funds should be programmed to purchase the incompatible use and acquire the necessary land rights or whether the affected shelter(s) should be abandoned or replaced elsewhere in the deployment area.

c. Joint Use Activities: This concerns mining activities that are permissible on lands in the MX deployment region which are not specifically withdrawn for MX. Certain activities such as mineral prospecting, mining, and mineral extraction (including blasting and overflights, if coordinated in advance with the Air Force) are allowable nonrestrictive activities which can occur on lands adjacent to MX shelter sites.

d. Joint Siting Review: As a part of the siting review process, site plans for each valley will be jointly reviewed by the states, BLM, and other parties. During this review, it would be expected that many case-by-case mining conflicts to be resolved prior to release of land to the Air Force.

Implementation of these policy elements by the Air Force will mitigate the impact of MX on the mineral industry.

1 "The Air Force Minerals Policy," a letter dated 9 April 1981 from Major General Forrest S. McCartney, Commander - Ballistic Missile Office, USAF, to Edward F. Spang, Nevada State Director, Bureau of Land Management.

3.0 STUDY METHODOLOGY

The review of the metallic, nonmetallic, and energy commodities potential of the MX Additional Valley Study Area consisted of:

o Research, procurement, and review of published and unpublished geological- and mineral-related literature and maps from federal and Nevada state government sources, including:

  - U.S. Geological Survey;
  - U.S. Bureau of Mines;
  - U.S. Bureau of Land Management;
  - U.S. Department of Energy;
  - Nevada Bureau of Mines and Geology; and
  - University of Nevada, Reno;

o Procurement and review of geological-, mineral-, and production-related data from professional groups, technical journals, trade associations, and private sources, including:

  - Rocky Mountain Association of Geologists;
  - Intermountain Association of Petroleum Geologists;
  - American Association of Petroleum Geologists;
  - Society of Economic Geologists;
  - Geological Society of America;
  - Society of Mining Engineers;
  - Nevada Mining Association; and
  - TerraScan Group, Inc.;

o Personal contacts with geologists affiliated with agencies and groups described above who are familiar with the geology and mineral (including oil and gas) occurrences within the study area;

o Mailing of questionnaires to 40 companies and individuals believed to be exploring or engaging in production activities within the study area, soliciting their input regarding exploration commodity of interest, area of interest, and general, nonproprietary data regarding exploration results;

o Field visits by geologists and engineers to document operating properties and areas of known intense exploration activity and mine development; and

o Engaging the services of geological and mineral economic consultants to provide reports of the mineral occurrences and potential, along with the geological setting of the occurrences within their area(s) of expertise. (See FN-TR-41, page 6 for a list of consultants contributing to this report).

The geological and mineral occurrence information obtained from the above described sources were reviewed, interpreted, and compiled into report form with accompanying maps illustrating interpretation of the relationship of the mineral commodity occurrences to intrusive and extrusive (volcanic) rocks, sedimentary environments and rock types, structural-tectonic features and trends, and geophysical anomalies. From these data, areas of potential for the various commodities investigated were outlined and presented in report and graphic format.

Map scales used in this report were dictated by the U.S. Army, Corps of Engineers and the U.S. Bureau of Land Management. Because of the small map scales, all data locations should be considered as approximate. <u>Areas interpreted in the report as having potential should be considered as approximately defined rather than possessing precise boundaries</u>.

4.0 PREVIOUS STUDIES

For information regarding previous studies in the study area, refer to the Regional Mineral Resources Survey (FN-TR-41), Section 4.0, which describes in detail the previous studies done in the Great Basin including the MX siting area. That description also applies to the Additional Valley Mineral Resources Survey Study Area. In addition, there are some publications which have been used to obtain extra information in the Additional Valley Study Area. The supplementary reference list in this report contains those publications.

5.0 RESULTS

The results of this study are presented in this section which summarizes the geological setting of the study area, interpretation of geological and geophysical data, mineral commodity occurrences, and energy-related resources. Accompanying the discussion of the results are the following nine drawings which delineate the occurrences and potential of various commodities.

Drawing No.	Map Title
1	Compilation of Mineral Potential in MX Deployment Areas
2	Compilation of Energy Potential in MX Deployment Areas
6	Commodity Occurrences with Mining Districts
11	Precious Metals Potential
12	Base/Ferrous Metals Potential
13	Nonmetallic and Industrial Minerals Potential
14	Uranium Potential
15	Oil and Gas Potential
16	Geothermal Favorability Map

Chart 1 describes location, geology, and production history of the Organized Mining Districts in the study area.

In addition to the occurrences and potential maps, there are six additional maps included in this section as follows:

Drawing	Map Title
4	Generalized Geological Map of the Study Area
5	Geology and Structure with Mining Districts
7	Favorable Sediments
8	Limonitic Alteration
9	Regional Aeromagnetic Map
10	Regional Gravity Map

Accompanying the generalized geological map of the study area is Chart 2 which serves as the explanation for Drawing 4. Chart 2

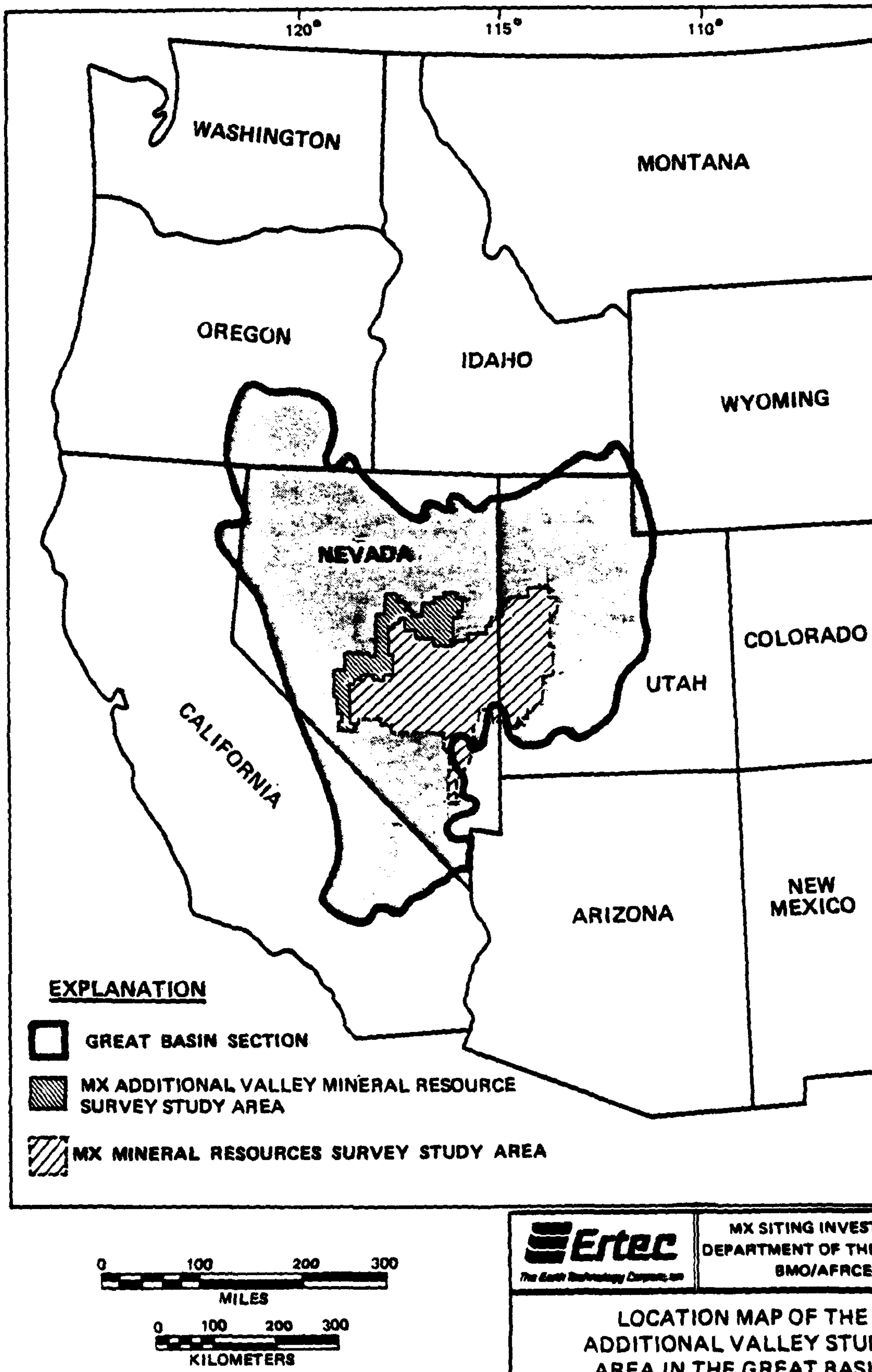
also presents a summary of the aggregate-use classification identified for each of the map units.

5.1 GENERAL GEOLOGIC SETTING OF THE ADDITIONAL VALLEY MINERAL RESOURCES SURVEY STUDY AREA

The following discussion will summarize the physiography, geologic history, tectonic framework, and stratigraphy of the study area. It emphasizes those elements of the geology that relate to mineral occurrence and potential.

5.1.1 Physiography

As shown in Figure 5-1, the MX Additional Valley Study Area consists of an arcuate stretch of land averaging 25 miles (40 m) wide and about 248 miles (400 m) long and adjoins the northern and western boundaries of the regional Mineral Resources Survey Study Area (see report FN-TR-41). It covers approximately 5886 mi^2 (15,250 km^2) of Esmeralda, Eureka, Lander, Nye, and White Pine counties in central Nevada and contains seven siting valleys (Big Smoky, Monitor, Kobeh, Newark, Long, Jakes, and Butte). The study area lies entirely within the Great Basin section of the Basin and Range Physiographic Province (as defined by Hunt, 1967; and Stewart, 1980) (Figure 5-1). Like most parts of central Nevada, the study area is characterized by a series of north-south trending mountain ranges and valleys which represent uplifted and down-dropped fault blocks. Materials, eroded from the uplifted blocks, have filled the adjacent basins commonly to depths of several thousand feet (Hunt, 1967). The valleys are mostly flat, averaging 6 to 8 miles (10 to 13 km)



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LOCATION MAP OF THE ADDITIONAL VALLEY STUDY AREA IN THE GREAT BASIN

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FIGURE 5-1

wide with internal drainage systems. Seven dry Quaternary lakes and several marshlands exist in the lower portions of the valleys.

The mountain ranges in the study area average between 48 and 96 miles (80 and 160 km) in length and up to 14 miles (24 km) in width. Foothills are generally lacking with the mountain fronts rising steeply from the valley floors. Average elevations of the valleys are about 4756 feet (1450 m), while the tops of the ranges average approximately 8910 feet (2700 m) above sea level. The highest point within the study area is the 11,939 feet (3618 m) peak of Mount Jefferson which is located in southern Toquima Range.

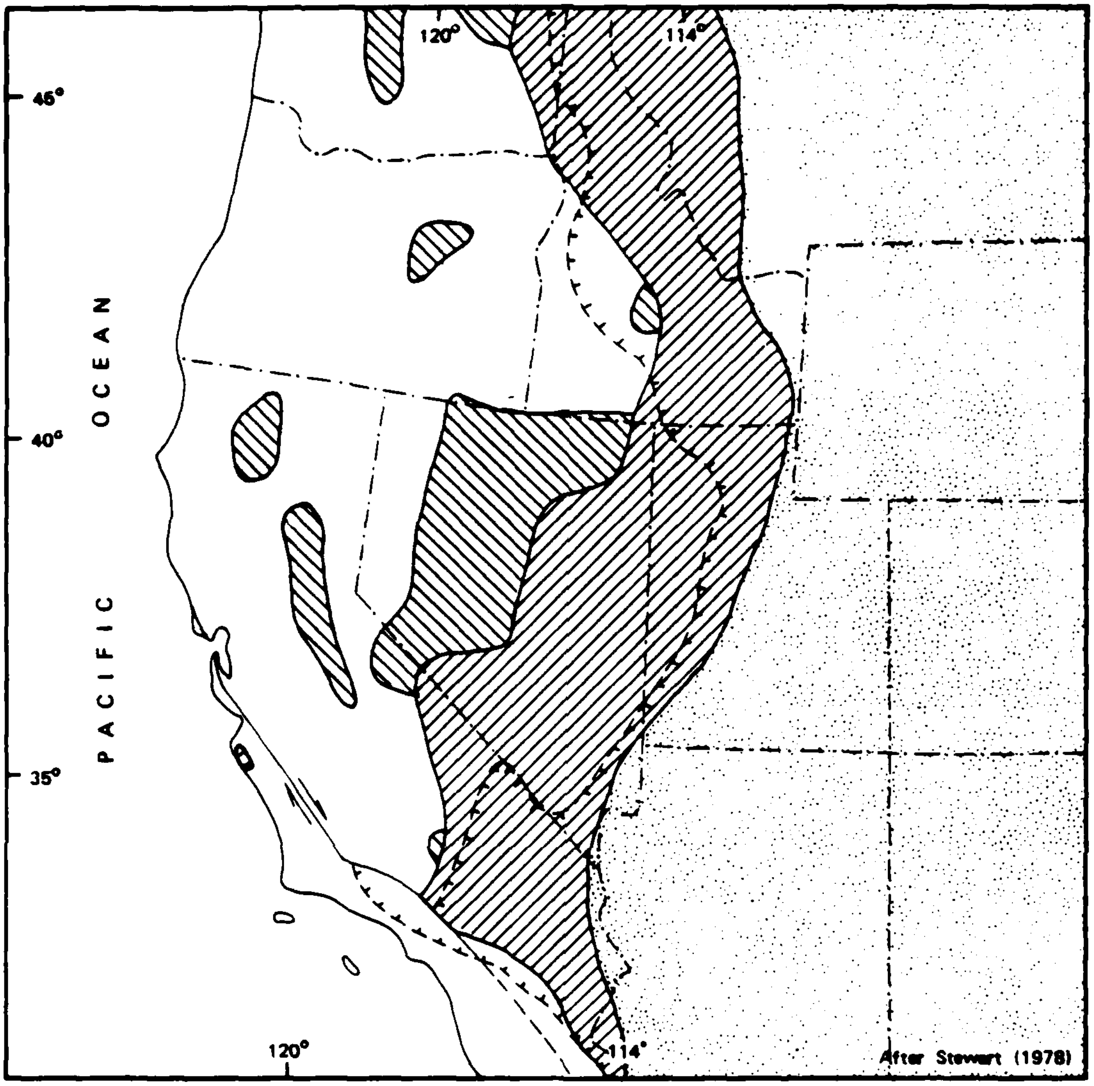
The region is characterized by a desert climate with generally hot summers and cold winters. Summer temperatures reach 100°F (38°C) in the valleys, while the higher elevations of the mountain ranges are much cooler. This thermal gradient produces strong winds which blow back and forth between the valleys and ranges. Winter temperatures average 32°F (0°C) but occasionally reach far below the freezing point (-40°F [-40°C]). Precipitation and humidity are relatively low with rainfall averaging less than 5 inches (13 cm) a year over most portions of the study area. The low rainfall accounts for the lack of perennial streams, rivers, and lakes in the region. Vegetation is also sparce. Sagebrush and low shrubs are common on valley floors. At higher elevations, where water is more abundant and humidity is higher, pinyon, cottonwoods, and junipers occur.

A result of this harsh desert condition is a sparce population within the study area. The largest community in the area is Tonopah which has a population less than 6000 (Department of the Army, Corps of Engineers, 1980). Small-scale agricultural activities are limited by the availability of ground water. In contrast, mining activities in the area are much greater.

State highways, including 6, 50, and 95, and county roads provide year-round access to the study area (see Drawing 2 of FN-TR-41 for a map of roads in the area).

5.1.2 *Geologic History and Tectonic Framework*

The MX Additional Valley Study Area is located within the Great Basin section of the Basin and Range Physiographic Province as defined by Hunt (1967) (Figure 5-1). The oldest rocks exposed in the area are of late Precambrian age. The early Precambrian formations are not exposed in the study area and, therefore, the geologic history and tectonic framework of this period are generally unknown. During late Precambrian and lower Cambrian time, a series of quartzite, siltstone, and carbonate rocks were deposited in the area. These rocks indicate the existence of a very shallow, rapidly subsiding sedimentary basin (or interrelated basins) in the Great Basin during that time. This basin is known as the Cordilleran geosyncline (Figure 5-2). The high rate of subsidence resulted in deposition of up to 19,800 feet (6000 m) quartzite and siltstone during late Precambrian and lower Cambrian time (Stewart, 1980). At present, the sediments of this geosyncline are exposed in eastern and central Nevada



Cordilleran Miogeosyncline

Cordilleran Eugeosyncline

Craton generally covered by a relatively thin veneer of Paleozoic rocks,

Approximate western extent of outcrops of Precambrian crystalline basement rocks.

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PRE–MESOZOIC TECTONIC SETTING OF WESTERN NORTH AMERICA

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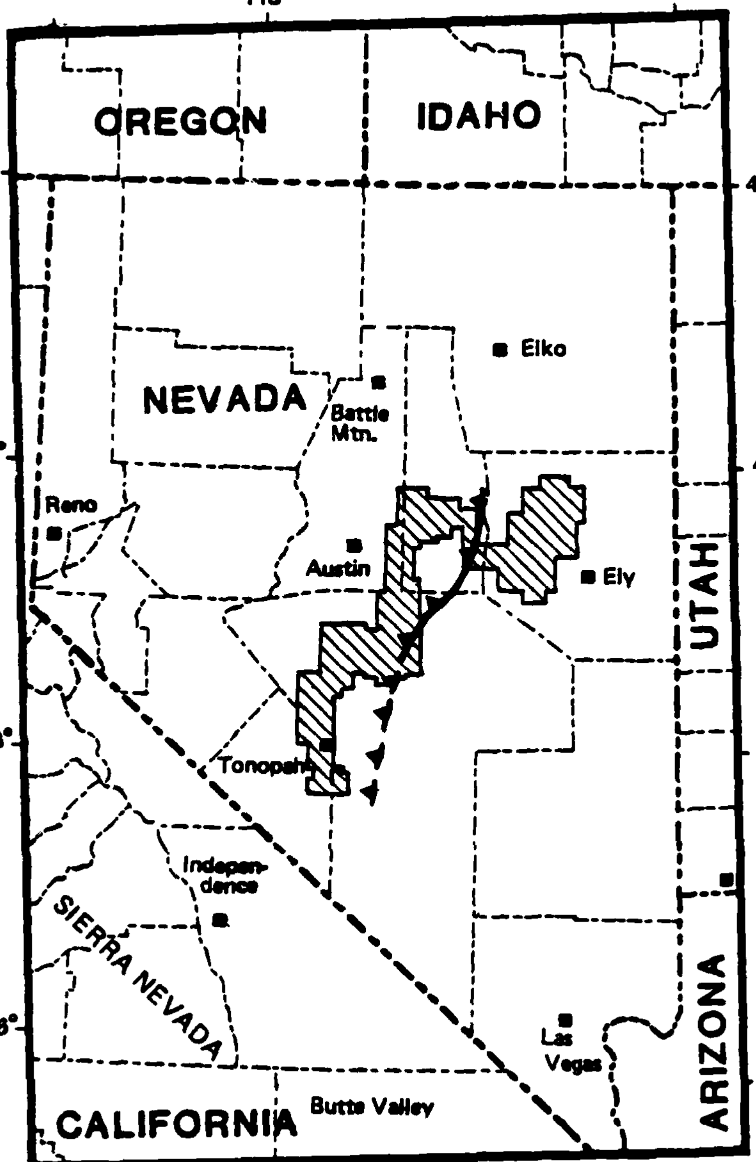
FIGURE 5-2

and western Utah. The western limit of the Cordilleran geosyncline is not well known because it is covered by Tertiary volcanic rocks. The western portion of this geosyncline was relatively deeper than the eastern portion, and rocks of eugeosynclinal facies of Paleozoic age occur within that portion. The deposits of the eastern portion of this geosyncline are of miogeosynclinal facies (Stewart, 1980). Deposition of a thick sequence of shallow marine sediments continued in the Cordilleran geosyncline from late Precambrian time until middle Ordovician time, during which a mild regional uplift and emergence occurred. Middle Ordovician rocks are missing from the study area and its surroundings (Stewart, 1980). Langenheim and Larson (1973) indicate that within the Great Basin, an unconformity occurs at the base of the Upper Ordovician Eureka Quartzite. Hose and Blake (1976) relate the absence of the middle Ordovician rocks of the area to the existence of a mild local epirogenic warping. According to Nolan and others (1956), an elongate positive area or linear swell, trending north-south, appears to have developed during early or middle Ordovician time. Stewart (1980) states that except for these epirogenic movements, no other evidence of Ordovician tectonic activity in Nevada has been reported. However, the occurrence of volcanic activity during lower and middle Ordovician time in the western portion of the Cordilleran geosyncline resulting in the deposition of chert, siliceous materials, and greenstone (Vinini and Valmy formations) could be evidence of magmatism during Ordovicician tectonic activities in western Nevada.

The northern part of the study area subsided during Upper Ordovician time and a series of dolomite, limestone, and quartzite beds were deposited in the area during the Silurian and Devonian periods. Deposits of Silurian and Devonian age, however, do not occur in the southern part of the study area around Tonopah indicating emergence of the area during that time.

During Devonian time, a significant orogeny, known as the Antler orogeny, occurred in central Nevada. The most conspicuous effect of this orogeny was a large overthrusting of the western facies of the Cordilleran geosyncline (eugeosynclinal facies) over the eastern facies of the same geosyncline (miogeosynclinal facies). This overthrust is known as the Roberts Mountains thrust (Figure 5-3). The Lower Paleozoic eugeosynclinal facies of the Cordilleran geosyncline consists mainly of chert, siliceous siltstone, feldspathic sandstone, and greenstone associated locally with limy sandstone, siltstone, and limestone.

The Roberts Mountains thrust sheet, which essentially consists of siliceous rock formations of eugeosynclinal facies, covers a large portion of the study area (Figure 5-3). The geologic map of Nevada (Stewart and Carlson, 1978) indicates that in the study area, the siliceous rock formations of the Roberts Mountains thrust sheet are exclusively allochthonous (formed elsewhere). Stewart (1980) indicates that autochthonous (formed in place) eugeosynclinal facies occur to the west and northwest of Nevada beyond the western limit of the study area. He also



SEE DRAWING 5 FOR REFERENCE

MX ADDITIONAL VALLEY MINERAL RESOURCE SURVEY STUDY AREA

LEADING EDGE OF THE ROBERTS MOUNTAINS THRUST, DASHED WHERE INFERRED OR UNCERTAIN, SAWTEETH ON UPPER PLATE

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LOCATION MAP OF THE STUDY AREA AND THE ROBERTS MOUNTAINS THRUST

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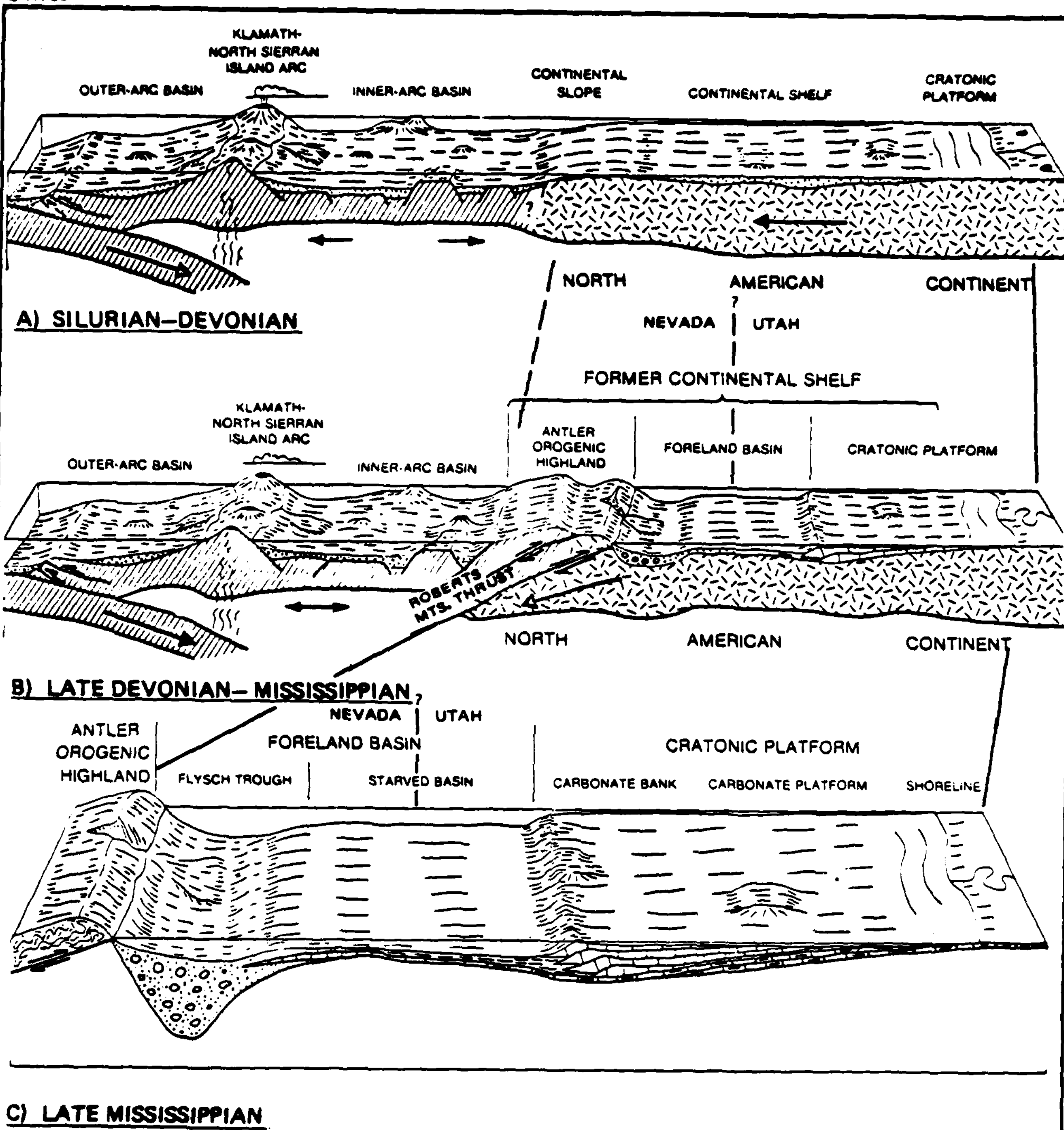
FIGURE 5-3

indicates that the autochthonous rocks of the Cordilleran miogeosyncline, west of the leading edge of the Roberts Mountains thrust, are only exposed in a few windows (where eroded areas of the thrust sheet reveal the underlying rocks).

The Antler orogeny also resulted in uplifting of some areas in central Nevada (including the study area) and formed linear swells or positive areas (Nolan and others, 1956). These positive areas, known as the Antler Orogenic Highland (Poole and Sandberg, 1977), received no sediment after uplift, trend generally north-south, and divide the geosyncline into basins. Langenheim and Larson (1973) confirm this by indicating that in large portions of the Great Basin, the Upper Devonian and Lower Mississippian rocks are missing.

Poole and Sandberg (1977) proposed a tectonic pattern for the Antler orogeny of the Great Basin based on a plate tectonic model (Figure 5-4). In this pattern, the Antler Orogenic Highland is a result of the Roberts Mountains thrust. Nolan and others (1956) distinguished two different elements of the structural history of the Eureka region. One is numerous thrust faulting, including the Roberts Mountains thrust, and the other is the formation of linear swells or positive areas (known as the Antler Orogenic Highland). They do not confirm the idea that the uplifting of the swells is related to the Roberts Mountains thrust. Stewart (1980) states that the origin of the Antler orogeny has been explained in terms of three concepts.



AFTER POOLE AND SANDBERG (1977)

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DIAGRAMS SHOWING RELATIONSHIP BETWEEN THE PALEOZOIC ISLAND-ARC AND THE NORTH AMERICAN CONTINENT (A AND B) AND DEPOSITIONAL SETTINGS OF FORELAND BASIN AND CRATONIC PLATFORM (C)

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FIGURE 5-4

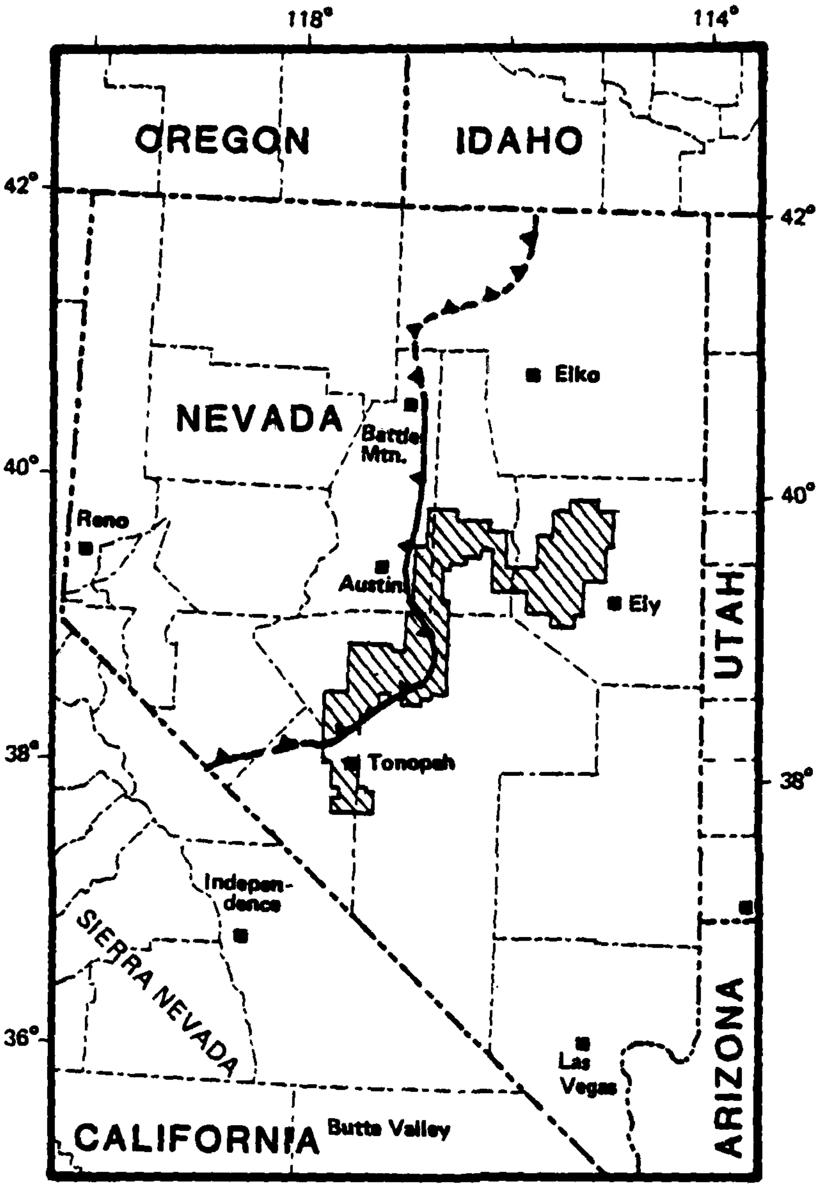
1. The geotectonic cycle;
2. Plate tectonics; and
3. An eastward-expanding uplift.

However, he does not confirm or strongly favor any one of these.

Ketner (1977a) suggests that after the uplifting of western Nevada in late Ordovician time (he does not discuss the cause of the uplift), rocks were shed eastward by a series of gravity slides that formed the Roberts Mountains allochthon. In any case, metamorphism, granitization, intrusive rocks, and intricate folding by the Antler orogeny do not occur in the study area.

The study area subsided after the Antler orogeny, and Mississippian, Pennsylvanian, and Permian deposits occur within the area. The Upper Paleozoic rock formations north of Tonopah are of eugeosynclinal facies. According to Silberling and Roberts (1962), another period of mountain building, known as the Sonoma orogeny, took place near the end of the Paleozoic era in the north-central part of Nevada. During this orogeny, deep water, Upper Paleozoic siliceous, and volcanic rocks are considered to have been structurally emplaced on a widespread thrust (the Golconda Thrust) over shallow-water autochthonous Upper Paleozoic rocks. Figure 5-5 shows that the leading edge of the Golconda thrust passes through a portion of the western section of the study area. Magmatism, metamorphism, and folding due to the Sonoma orogeny does not occur in the study area.

Contemporaneous with the Sonoma orogeny, the study area was uplifted by epeirogenic movements of Upper Permian age. Within



From Stewart, 1980

MX ADDITIONAL VALLEY MINERAL RESOURCE STUDY AREA

LEADING EDGE OF THE GOLCONDA THRUST, DASHED WHERE INFERRED OR UNCERTAIN, SAWTEETH ON UPPER PLATE

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LOCATION MAP OF THE STUDY AREA AND THE GOLCONDA THRUST - SONOMA OROGENY

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FIGURE 5-6

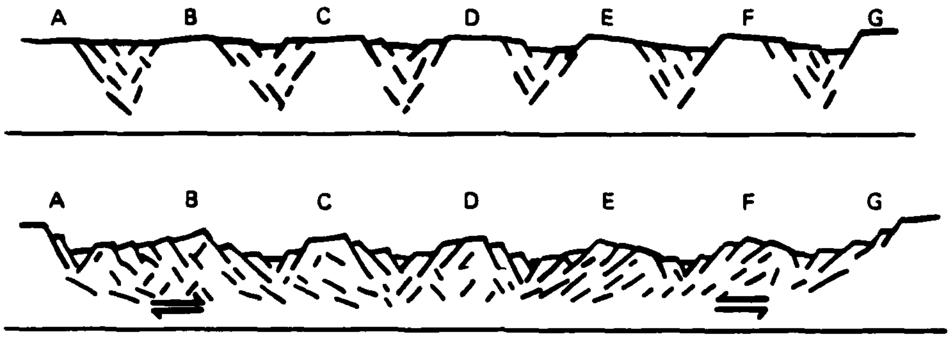
the study area, the only Triassic rocks that occur are the Lower Triassic Moenkopi Formation. They occur in two localities, the first one about 27 miles (45 km) northwest of Ely and the second approximately 38 miles (64 km) north of Tonopah. Similarly, the only Jurassic rocks that crop out in the study area are in a small outcrop of the Lower to Middle Jurassic Dunlap Formation which occurs approximately 30 miles (50 km) north-northwest of Tonopah. The Cretaceous rocks in the study area are also limited to a few small outcrops of the Upper Cretaceous continental Newark Canyon Formation around Eureka.

Generally, the study area can be considered as a Mesozoic highland. Complex tectonic events of Mesozoic age, such as the Nevadan, Laramide, and Sevier orogenies (Stewart, 1980; and Baker III *and others*, 1972) occurred in the Great Basin, but none occurred within the study area. Nevertheless, large-scale magmatic activities occurred during Jurassic and Cretaceous time resulting in the intrusion of large granitic plutons which are exposed around Manhattan and Eureka.

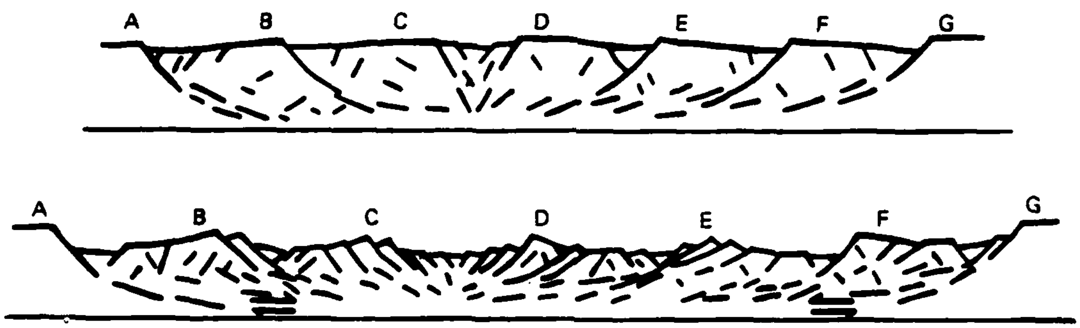
The compressive thrust faulting and shearing characteristic of the Paleozoic and Mesozoic eras changed in character during the Cenozoic era, and extensional block faulting became most prevalent. Cenozoic tectonism was prefaced by intense volcanism which covered large areas in Nevada including the western portion of the study area. A few large calderas are located north of Tonopah within and adjacent to the study area. Most of the volcanic rocks occurring in the study area are 34 to 17

million years old (Oligo-Miocene age). However, some volcanic rocks around Ely and Eureka are 43 to 34 million years old and some volcanic rocks around Tonopah are 17 to 6 million years old (McKee, 1971; and Stewart, 1980). These volcanic rocks are mainly andesitic and rhyolitic in composition.

Extensional block faulting commenced about 17 million years ago (Stewart, 1980) possibly in response to the subsurface weakening of the crust by extrusion of the voluminous middle Tertiary volcanics. The major basins and ranges that characterize the present-day topography were produced as a result of this extensional block faulting. The linear segments that were uplifted along normal high-angle faults formed the mountains, while the adjacent segments subsided and formed the valleys. Meister (1967) and Carlson and Mabey (1963) state that the depth of valley fill locally may be more than 9000 feet (3000 m), and consequently, structural relief between the lowest part of bed-rock areas under valleys to the highest parts of adjacent mountains generally range from about 6600 to 16,500 feet (2000 to 5000 m). Stewart (1978) states that for describing Cenozoic structures in the Great Basin, two general models of basin-range structure have been proposed, of which he indicated a preference for the horst-and-graben model (Figure 5-6, Model A). In this model, basin-range structures are produced by the fragmentation of an upper crustal slab over a plastically extending substratum. The other model relates the structure to a system of structural blocks along curving downward-flattening normal



MODEL A HORST AND GRABEN FORMED BY FRAGMENTATION ABOVE PLASTICALLY EXTENDING SUBSTRATUM (FROM STEWART, 1978)



MODEL B TILTED BLOCKS RELATED TO DOWNWARD-FLATTENING–LISTERIC FAULTS (FROM LOWELL AND OTHERS, 1975)

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TECTONIC MODELS PROPOSED FOR THE DEVELOPMENT OF BASIN AND RANGE STRUCTURE (SHOWING EARLY AND LATE STAGES OF DEVELOPMENT)

30 APR 81 FIGURE 5-6

faults (listric faults of Lowell and others, 1975). The uplifted part of an individual block forms a mountain, and the downtilted part of the same block forms a valley (Figure 5-6, Model B). Evaluating the relative merits of these two models is not easy, and structures in the Basin and Range province probably involve elements of both models. The Basin and Range faulting has continued throughout the Cenozoic era and some are historic (Stewart, 1980).

Another feature of the late Cenozoic tectonic framework of Nevada is the occurrence of a few major strike-slip faults in the region. Locally, they may become a major feature, but the major ones do not occur within the study area.

The sedimentary rocks of Tertiary age within the study area are limited to Miocene tuffaceous rocks deposited in shallow intermountain basins around Tonopah and Ely (Stewart and Carlson, 1978). In many cases, they occur in low hills, along washes, and in isolated patches within broad valleys. Less commonly, they occur in the mountain ranges. These rocks were deposited on the down-dropped fault blocks formed during the development of basin-range structure.

5.1.3 Stratigraphy

Within the MX Additional Valley Mineral Resources Survey Study Area, approximately 50 percent of the bed rock is obscured beneath Quaternary alluvial deposits. In addition, large areas in the western portion of the study area are also covered by Tertiary volcanic rocks. As a result, information about the

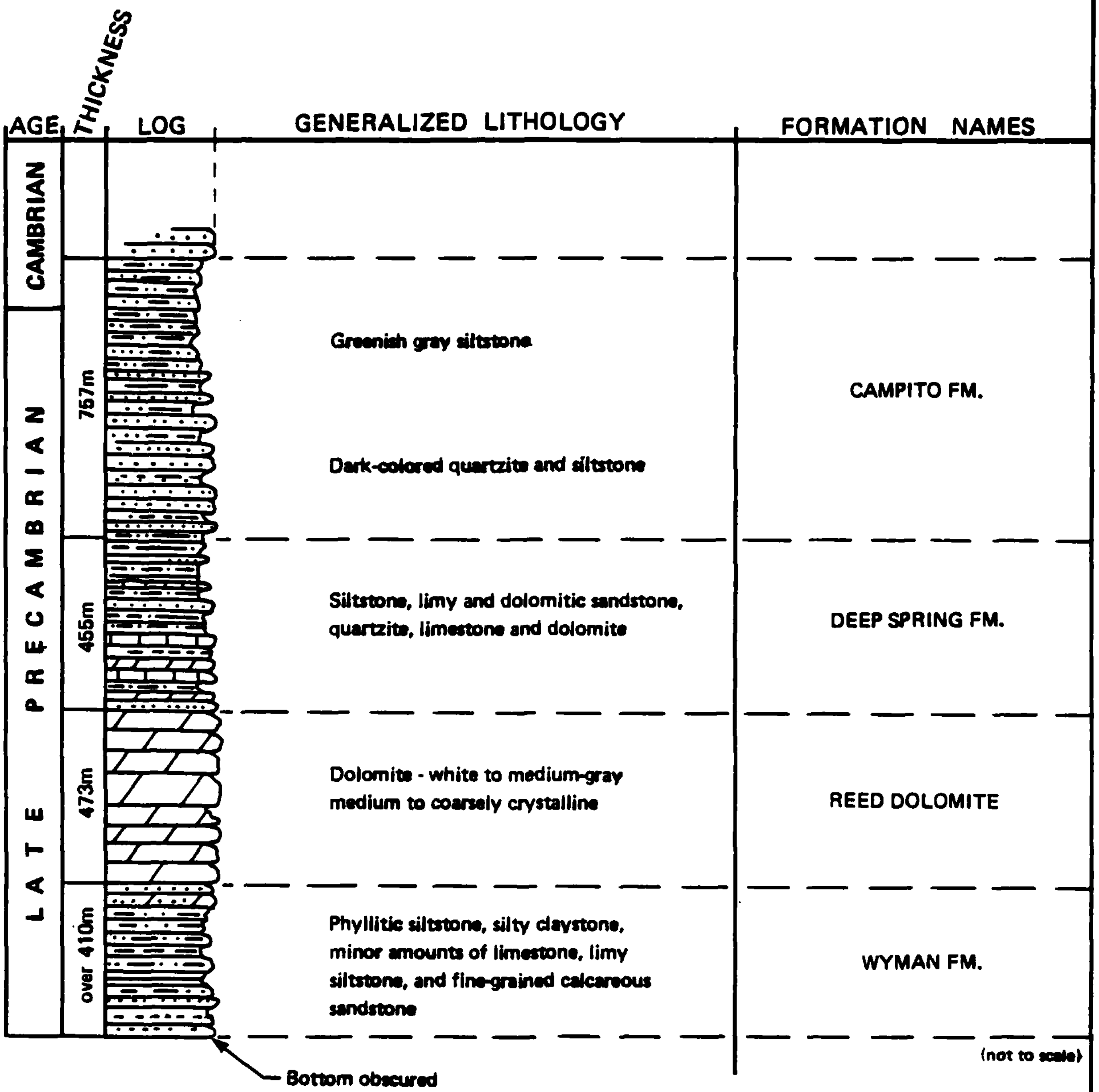
stratigraphy of pre-Tertiary rock sequences within the study area and immediate vicinity is insufficient, and the history of deposition in those areas is understood only in broad regional terms. The accompanying generalized geologic map (Drawing 4) and the following discussions and descriptions are a condensed summary of the stratigraphic history of the area.

Many workers have published data on various aspects of the stratigraphy of the Great Basin and Cordilleran Geosyncline which cover the study area. Of the many such publications available, those by Albers and Stewart, (1972), Cornwall (1972), Hose, Blake and Smith (1976), Kleinhample and Ziony (1967), Roberts, Montgomery and Lehner (1967), Stewart (1980), Stewart, McKee and Stager (1977), and Stewart and Carlson (1978) were utilized in writing this section.

5.1.3.1 Precambrian Era

The oldest rocks exposed in the study area are of late Precambrian age and limited outcrop extent. A few outcrops of this age occur around Tonopah in the Lone Mountain, Montezuma, and south San Antonio mountains. A single large outcrop also occurs in the Egan Range, approximately 30 miles (60 km) north of Ely. These rock outcrops generally consist of siltstone, sandstone, quartzite, dolomite, and a minor amount of limestone.

Figure 5-7 shows a generalized stratigraphic column of the late Precambrian rock sequences in the Tonopah region (Albers and Stewart, 1972). Similar lithology and stratigraphic sequences exist in the late Precambrian formation north of Ely. These



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LATE PRECAMBRIAN ROCK SEQUENCE
IN THE TONOPAH REGION

Compiled from Albers and Stewart, 1972

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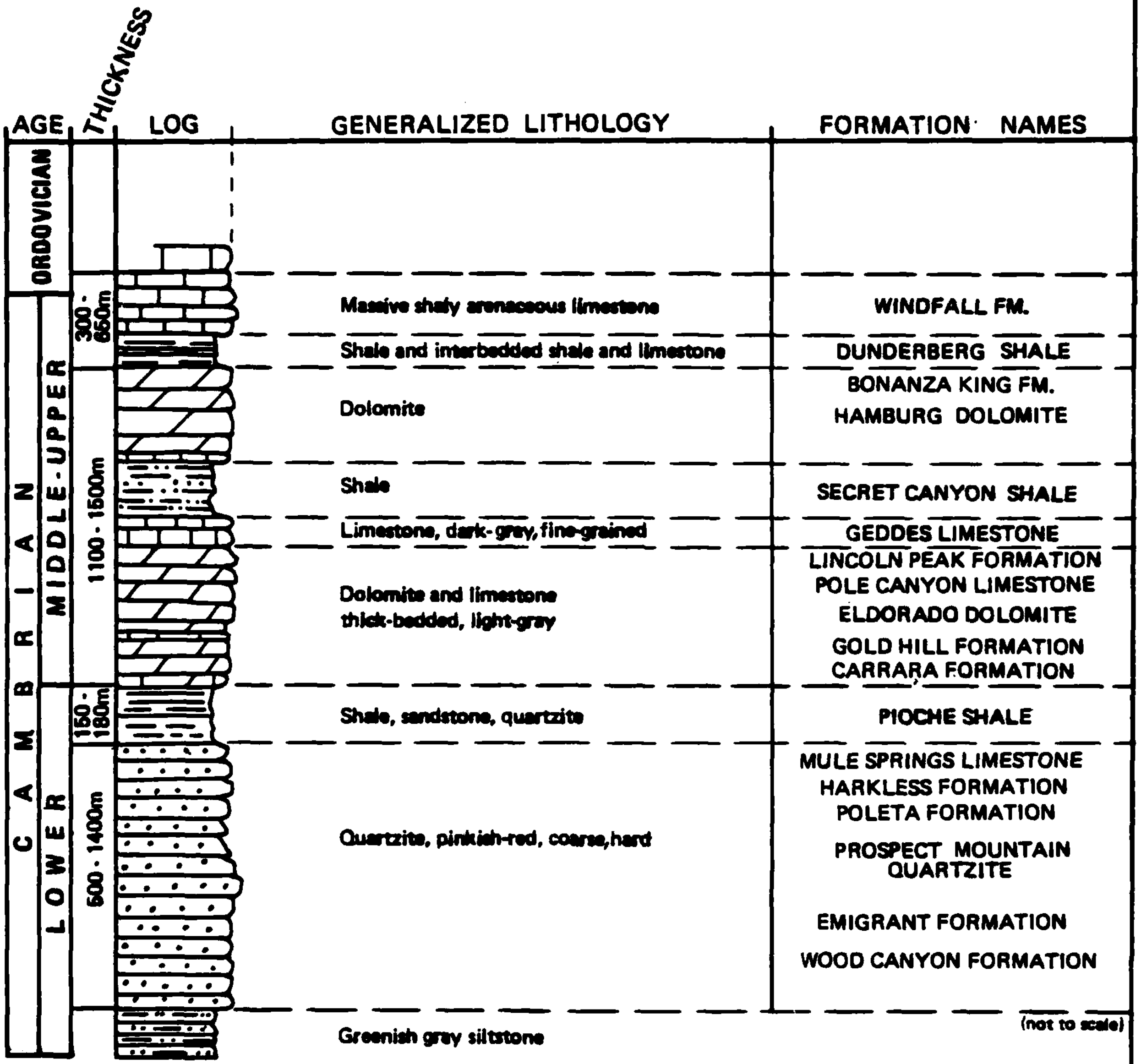
FIGURE 5-7

rocks were deposited in a shallow water near shore environment and lateral facies changes are common. Because fossils have not been found in these rocks, their age and stratigraphic position are inferred from their relationship to the lowest Cambrian rocks that overlie them.

5.1.3.2 Paleozoic Era

A. Cambrian Period - Cambrian rock sequences occur in most of the ranges in the study area. Figure 5-8 shows a generalized stratigraphic column of the Cambrian rock sequences around Eureka and Ely within the northern portion of the study area. The lower Cambrian formations consist of a thick sequence of coarse pinkish-red quartzite overlain by a persistent shale sequence. The middle and upper Cambrian rocks consist of fossiliferous dolomite, shale, siltstone, and limestone. These rocks were deposited in the Cordilleran geosyncline on the continental shelf in a very shallow depositional condition. As a result, a lateral change of facies is very common. The lithology and stratigraphy of the Cambrian rock sequences exposed in the southwest portion of the study area are essentially similar to Figure 5-8 except in the upper part of the sequence where siliceous material and chert locally occur.

This description pertains to the autochthonous Cambrian outcrops within the study area. There are also allochthonous Cambrian rocks in the area which belong to the Cordilleran eugeosynclinal facies of western Nevada (outside of the study area). They occur in the thrust sheets of the Antler orogenic belt (Stewart,



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CAMBRIAN ROCK SEQUENCE IN THE
EUREKA AND NW ELY REGIONS

Compiled from Roberts, Montgomery and Lehner, 1967'

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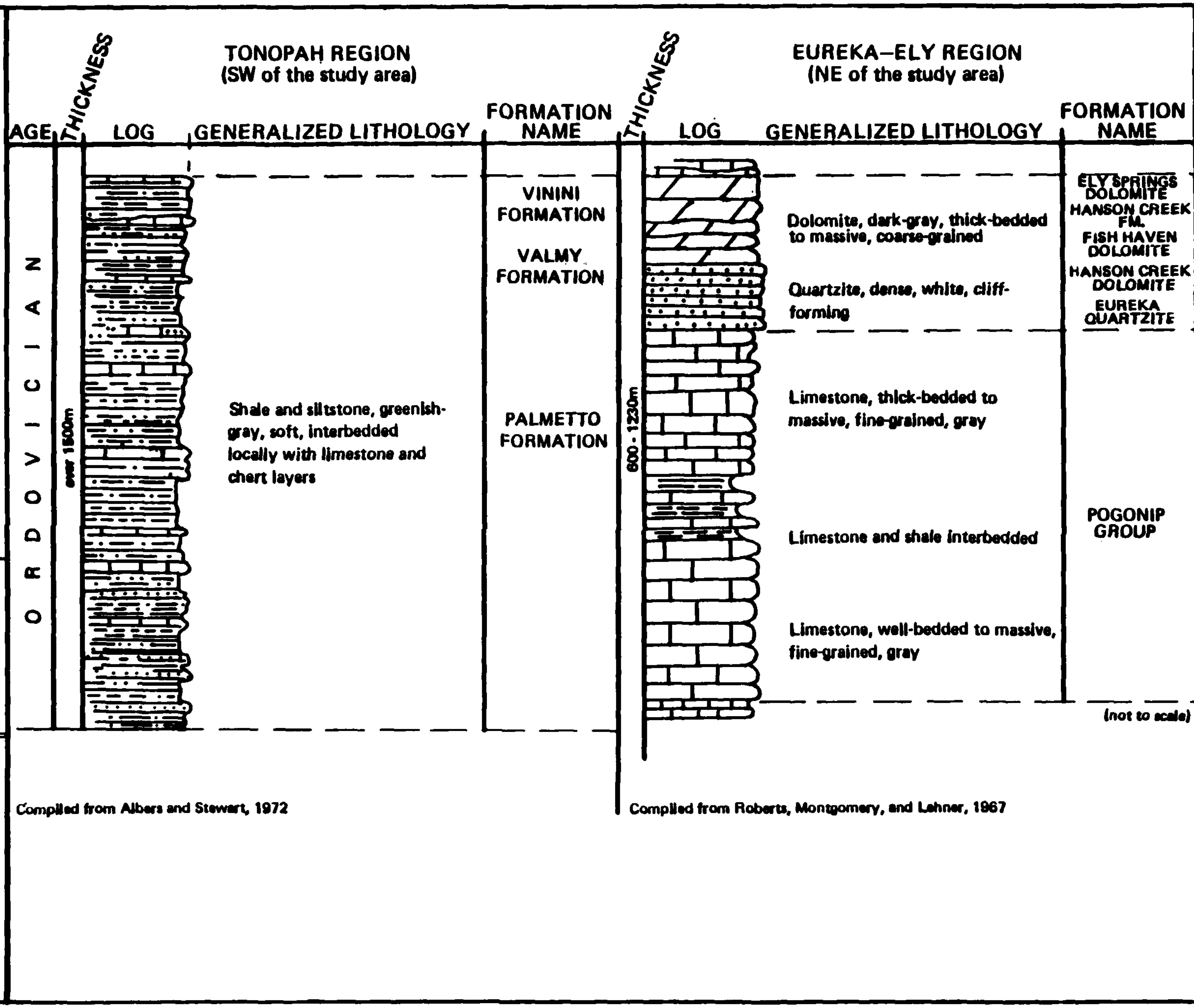
FIGURE 5-8

1980) west of the leading edge of the Roberts Mountains thrust (Figure 5-3). These rocks contain many feldspathic sandstone layers. Within the study area, they occur in the Toquima Range, Roberts Mountains, and Toiyabe Range. The development of the Cordilleran eugeosyncline started in late Cambrian and early Ordovician time. Eugeosynclinal facies in late Cambrian time contain essentially interbedded feldspathic sandstone layers in the rock sequence (Stewart, 1980).

B. Ordovician Period - Ordovician rock sequences are pervasive throughout the study area and generally consist of two different facies; a siliceous facies around Tonopah and a carbonate facies around Eureka, Ely, and in Nye County. Figure 5-9 shows a generalized stratigraphic column of these rock sequences. Around Tonopah (in Esmeralda County), the rock sequences consist essentially of shale and siltstone. Locally, these sequences are interbedded with minor amounts (less than 20 percent) of limestone, chert, and association of chert and limestone layers. They occur mainly in the Montezuma Range and Lone Mountain area.

Around Ely and Eureka, the depositional environment was different, and the Ordovician rock sequences in that area consist chiefly of limestone in the lower part, quartzite in the lower half of the upper part, and dolomite in the uppermost part (Figure 5-9). These lithologies and descriptions pertain to the autochthonous rock sequences in the study area. There are also Ordovician rock outcrops of the eugeosynclinal facies (Valmy Formation) of western Nevada in the study area. These



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ORDOVICIAN ROCK SEQUENCES
IN THE STUDY AREA

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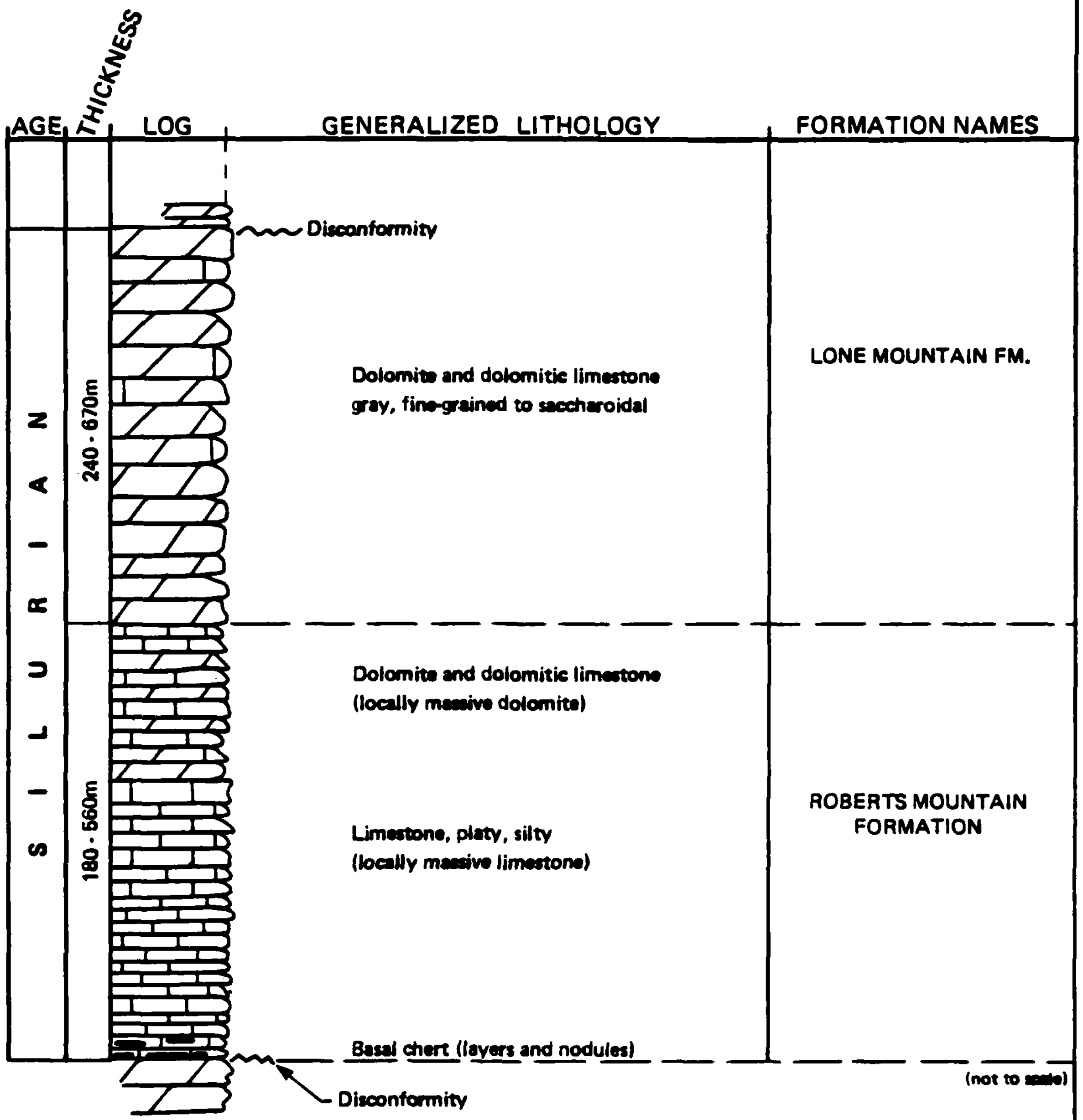
FIGURE 5-9

rocks, located west of the leading edge of the Roberts Mountains thrust, occur in the allochthonous thrust sheets. In places, the rock sequences of the eugeosynclinal facies contain greenstone, volcanic rocks, and pillow lavas.

C. Silurian Period - Silurian fossiliferous rock sequences occur extensively in the northern portion of the study area but are generally absent in the Tonopah region except for a single allochthonous rock outcrop located approximately 7.5 miles (12 km) north of Tonopah. This rock outcrop represents a thrust sheet consisting of siliceous and volcanic rocks, such as chert, quartzite, and greenstone. Figure 5-10 shows a stratigraphic column of the Silurian rock sequences in the Eureka and Ely regions. They generally consist of thin-bedded (locally massive), silty limestone in the lower half and dolomite in the upper half. Thin layers of dolomite and dolomitic limestone, representing a transitional facies change between limestone and dolomite, are interbedded in the middle part of the sequence. Bluish-black chert (nodules and layers) occur in the basal part of the Silurian rock sequence (Roberts, Montgomery, and Lehner, 1967). Langenheim and Larson (1973) show regional disconformities at the base and top of the Silurian rock sequences. In places, they show angular unconformities at the base and top of the Silurian rock sequences. Lateral change of facies in the Silurian rock sequences also commonly occur.

D. Devonian Period - Devonian rock sequences occur in all the ranges of the northern portion of the study area and the Hot



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SILURIAN ROCK SEQUENCE IN
THE EUREKA AND ELY REGIONS

Compiled from Roberts, Montgomery and Lehner, 1967

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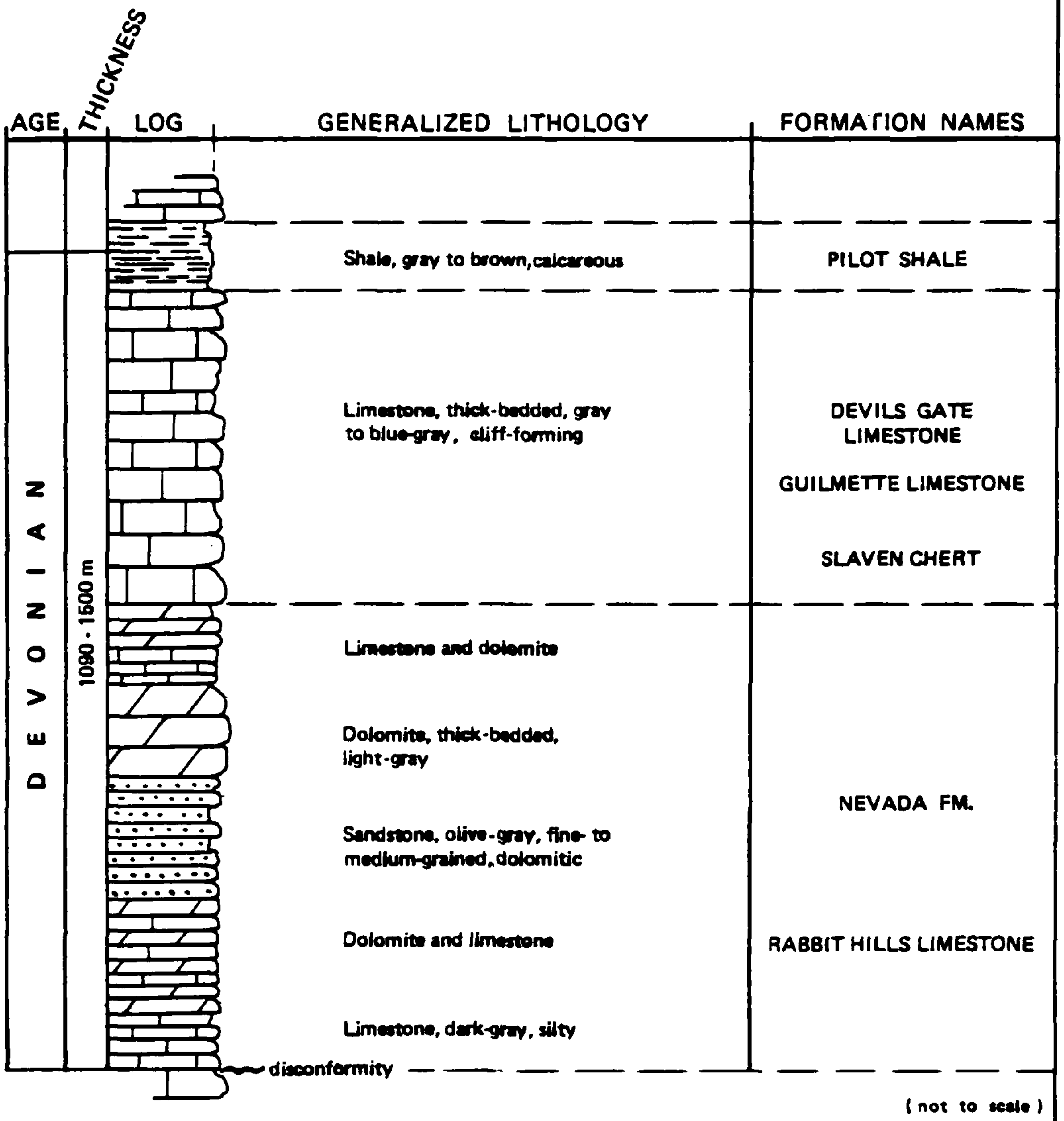
FIGURE 5-10

Creek, Monitor, and Toquima ranges. There are no outcrops of Devonian rocks in the southwestern portion of the study area because it was emergent during the Silurian and Devonian as a result of the Antler orogeny. As shown in Figure 5-11, the Lower Devonian consists chiefly of dolomite interbedded with limestone layers. A sandstone unit approximately 660 feet (200 m) thick occurs in the middle part. The rocks of the Upper Devonian period consist of thick-bedded, gray, cliff-forming limestone overlain by uppermost Devonian calcareous gray shale.

The Devonian rock sequences are fossiliferous, and disconformities (locally angular unconformities) occur at the top and bottom. Lateral change of facies is common.

E. Mississippian Period - Mississippian rock sequences are exposed in all the ranges of the northern portion of the study area and the Monitor and Hot Creek ranges. Figure 5-12 shows the stratigraphic column of the Mississippian rock sequences in those regions. The upper part of the Pilot Shale is transitionally overlain by approximately 330 feet (100 m) of a persistent, hard, cliff-forming limestone known as the Joana Limestone (Keroher and others, 1966). This limestone is locally dense, porcelaneous, and coarsely crystallized. Overlying rock formations are chiefly of shale, silt, sandstone, and conglomerate locally up to 9250 feet (2500 m) thick with the change of facies and thicknesses common.y occurring.

To the west and southwest (Tonopah region), rocks of definite Mississippian age have not been identified. The area lies



Compiled from Roberts, Montgomery, and Lehner, 1967

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DEVONIAN ROCK SEQUENCE
IN THE EUREKA REGION

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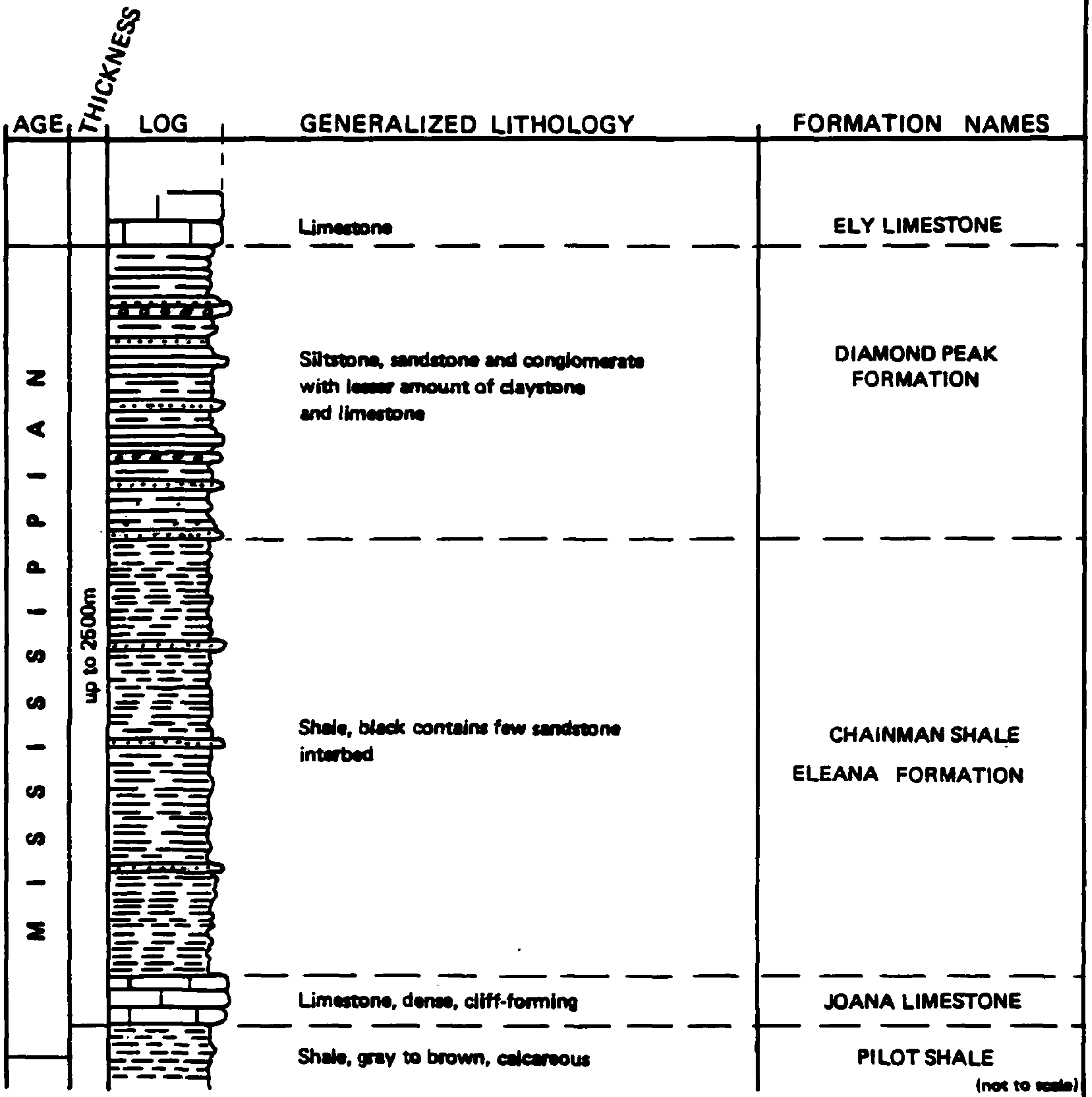
FIGURE 5-11



Compiled from Langenheim and Larson, 1973

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MISSISSIPPIAN ROCK SEQUENCE
AROUND ELY AND EUREKA

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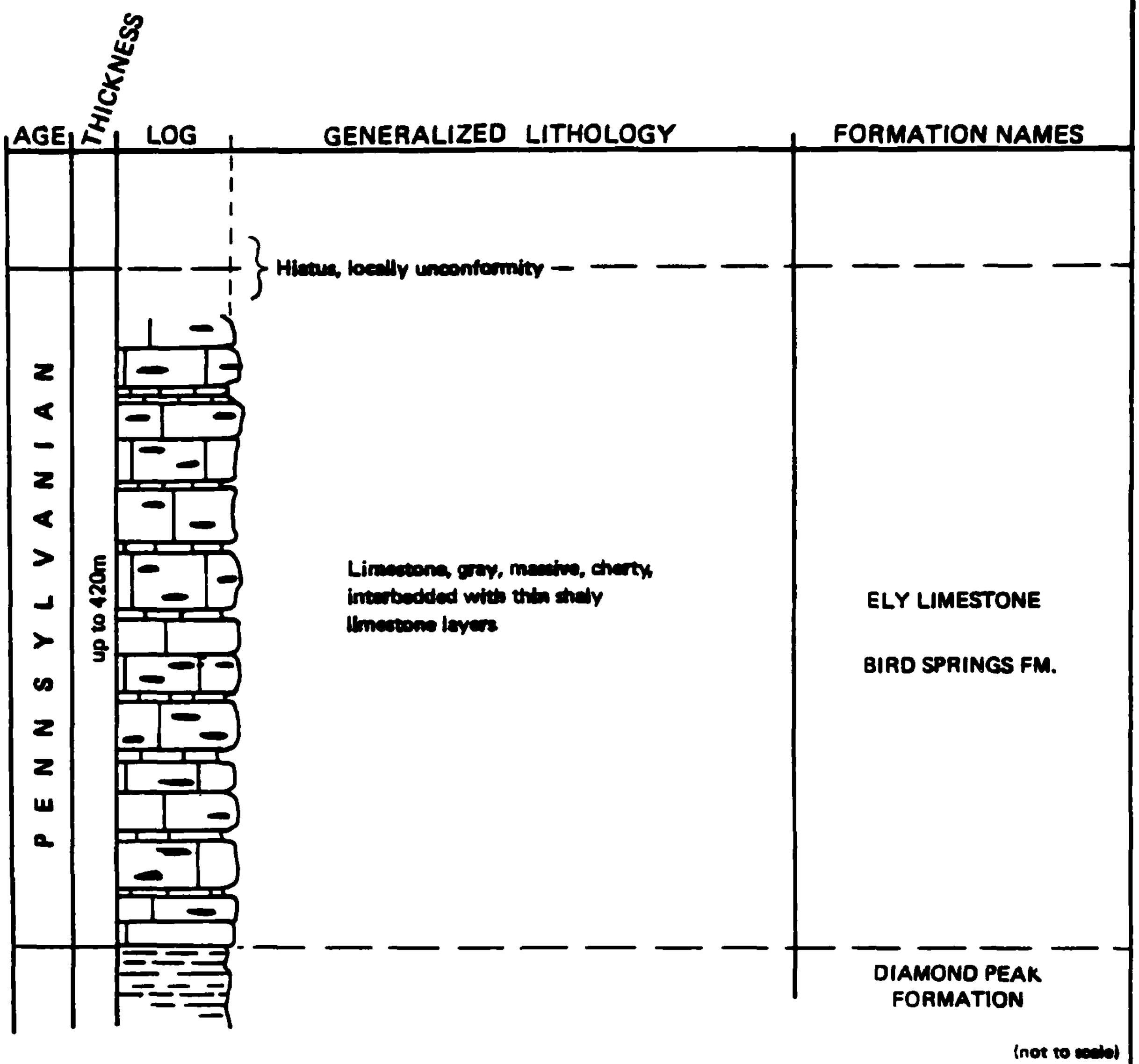
FIGURE 5-12

within the Antler Orogenic Highland emerged since Silurian time. The thick clastic rocks of the Chainman shale and Diamond Peak Formation have been shed eastward from the Antler orogenic highland into the Mississippian sedimentary basins around Eureka and Ely.

In the San Antonio Mountains, about 10 miles (16 km) north of Tonopah, a few outcrops of massive unfossiliferous limestone, possibly of Mississippian age, are also exposed. The area is intricately faulted and largely covered by Cenozoic formations and definite evidence for their age is not available.

The contacts between the Mississippian rocks and overlying and underlying rocks are transitional.

F. <u>Pennsylvanian Period</u> - Fossiliferous Pennsylvanian rock sequences known as the Ely limestone (Keroher and others, 1966) occur over most of the study area except in the extreme southwest portion. As shown in Figure 5-13, they consist of up to 1386 feet (420 m) of gray, massive, cherty limestone interbedded with thin, shaly limestone layers. Cherts are a characteristic feature of these sequences. The Ely limestone has a persistent lithology in central and eastern Nevada, including the Ely and Eureka region, but in the western part of the study area, the thickness and facies change. According to Stewart (1980), this limestone dies out to the west of the study area. The top of the Pennsylvanian rock sequences indicates a regional uplifting of the study area resulting in a sedimentary gap during the uppermost Pennsylvanian and lowermost Permian time. Locally,



Compiled from Roberts, Montgomery and Lehner, 1967

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PENNSYLVANIAN ROCK SEQUENCE AROUND ELY AND EUREKA

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FIGURE 5-13

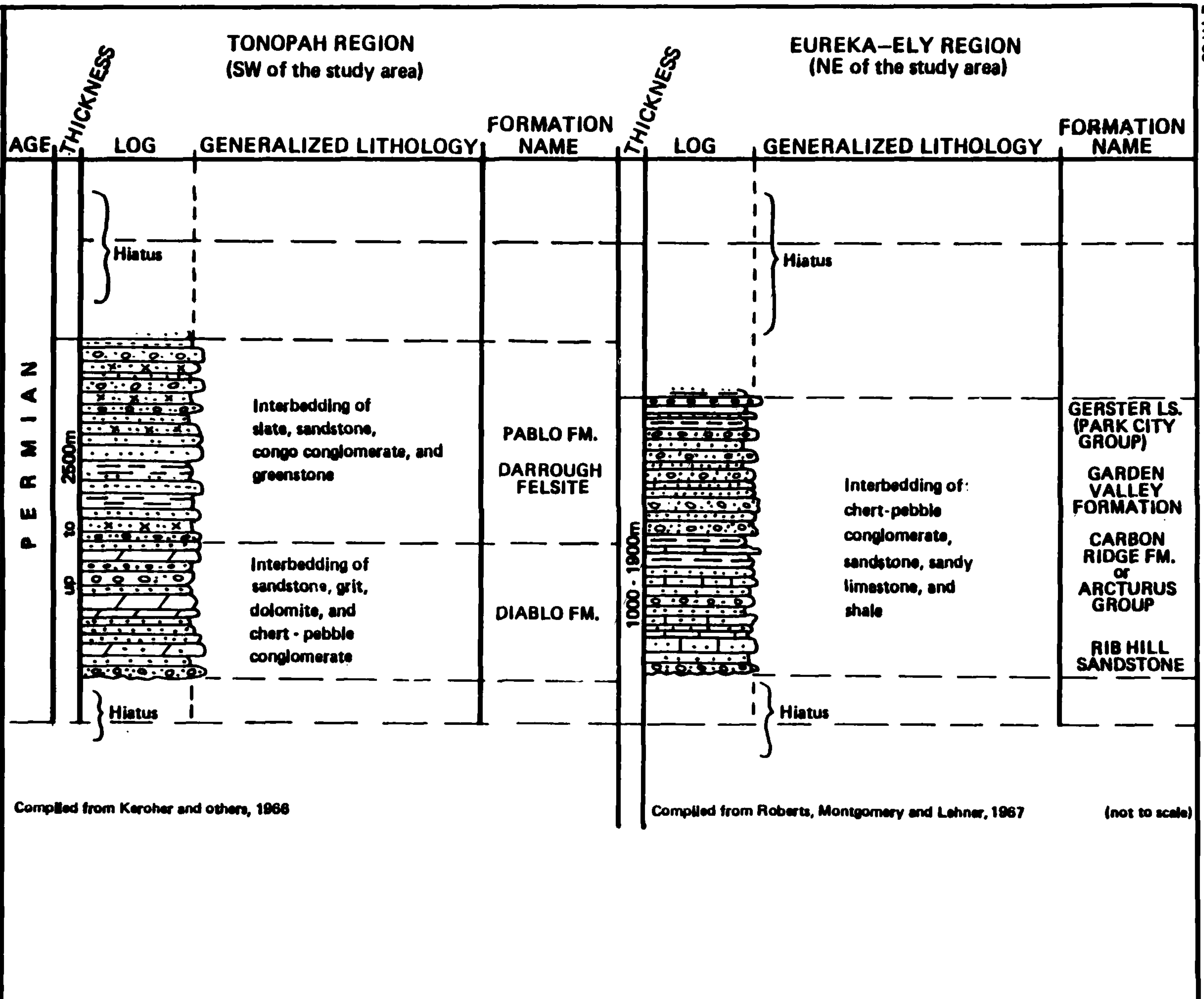
unconformities occur between the Permian and Pennsylvanian strata.

G. Permian Period - Permian rock outcrops occur over most of the study area except for the region south of Tonopah. These rocks are generally fossiliferous. As shown in Figure 5-14, the rock formations consist mainly of chert-pebble conglomerate, sandstone, grit conglomerate, dolomite, and shale. In the Tonopah region, the upper part of the Permian rock sequences contain slates, greenstones, and andesitic lava flows (Keroher and others, 1966). Hiatuses occur at the base and top of the rock sequences. Generally, disconformities and locally angular unconformities have been found at the contact between the Permian strata and overlying as well as underlying strata.

5.1.3.3 Mesozoic Era

The Cordilleran geosyncline, which was well-developed in early Paleozoic time, disappeared during Permian time, and no major sedimentary basin replaced it during Mesozoic and Cenozoic times. Langenheim and Larson (1973) indicate that during the Mesozoic time, only scattered shallow sedimentary basins existed in central Nevada, and most of the region remained emergent during that time.

A. Triassic Period - Stewart (1980) states that the Triassic rocks of Nevada occur in two separate regions (eastern and western), each with its own distinctive lithologic sequence. Rocks of the eastern region are separated from rocks of the western region by an area lacking Triassic rocks. In early



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PERMIAN ROCK SEQUENCES IN THE STUDY AREA

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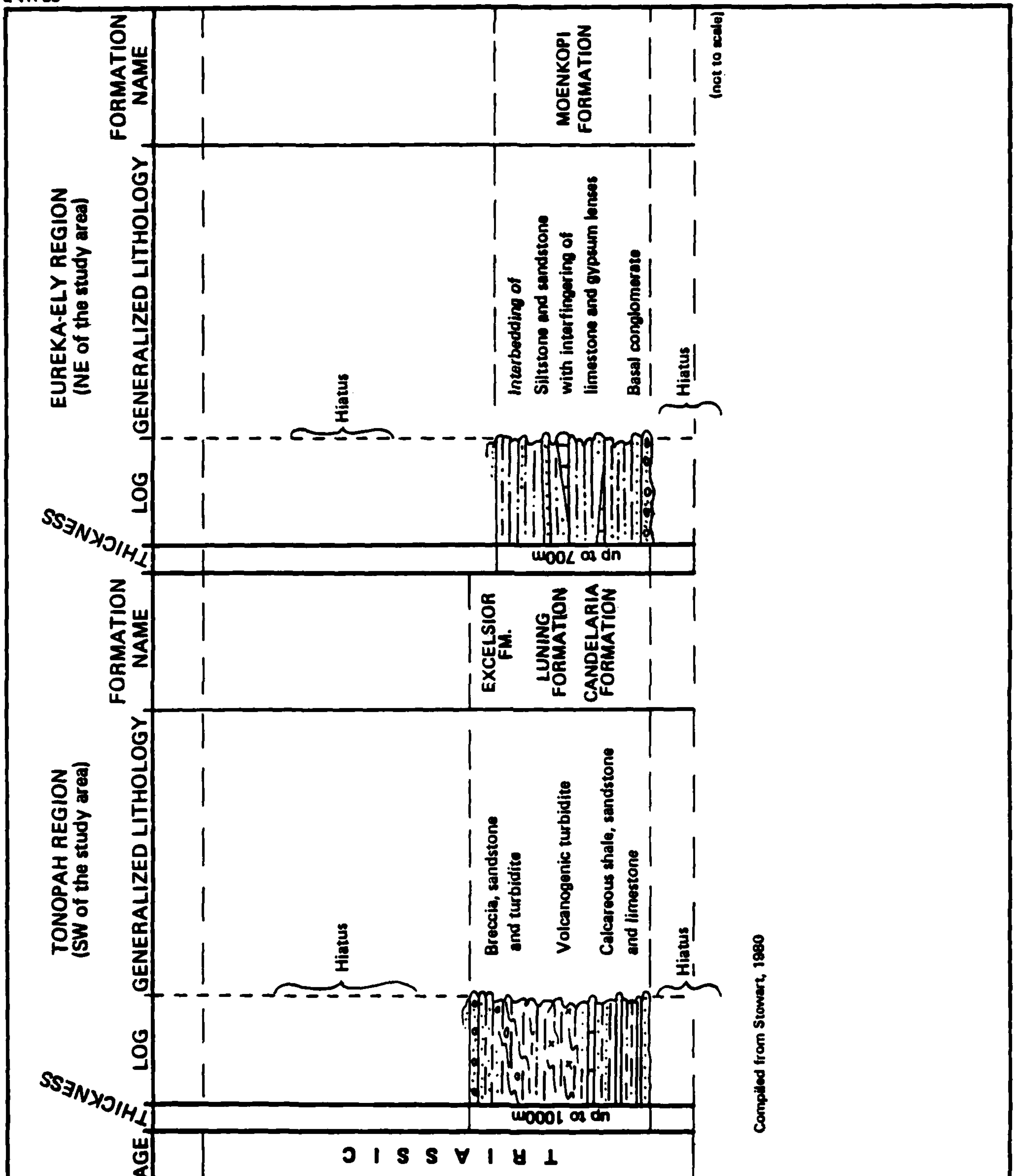
FIGURE 5-14

Triassic time, this area probably was an upland separating the two basins of deposition. The study area lies within this Lower Triassic upland, and there is only one minor Triassic outcrop 40 miles (63 km) north of Tonopah belonging to the Triassic sedimentary basin of western Nevada (western region) and three small outcrops approximately 28 miles (45 km) northwest of Ely belonging to the Triassic sedimentary basin of eastern Nevada (eastern region). As shown in Figure 5-15, the Triassic rock sequences northwest of Ely consist of siltstone and fine-grained sandstone with interfingering units of limestone, silty limestone, gypsum, and gypsiferous shale with conglomerate occurring at the base. The Triassic outcrop north of Tonopah consists of calcareous shale, sandstone, and limestone in the lower part, volcanogenic turbidite in the middle part, and turbidite and breccia near the top. No volcanic or plutonic rocks of Triassic age occur in the study area.

B. Jurassic Period - The study area remained an upland during Jurassic time. Rocks of Jurassic age are generally not exposed in the study area, however, one small outcrop, approximately 31 miles (52 km) north-northwest of Tonopah, does occur. It belongs to the Jurassic sedimentary basin of west Nevada (Stewart, 1980). In this locality, the Jurassic rock sequence consists of a heterogeneous mixture of breccia, conglomerate, sandstone, volcanic rocks (Figure 5-16). The thicknesses reach up to 1650 feet (500 m) indicating extensive volcanic activity in the western part of the basin associated with the intrusion of granitic plutons. In two localities within the study area,



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TRIASSIC ROCK SEQUENCES
IN THE STUDY AREA

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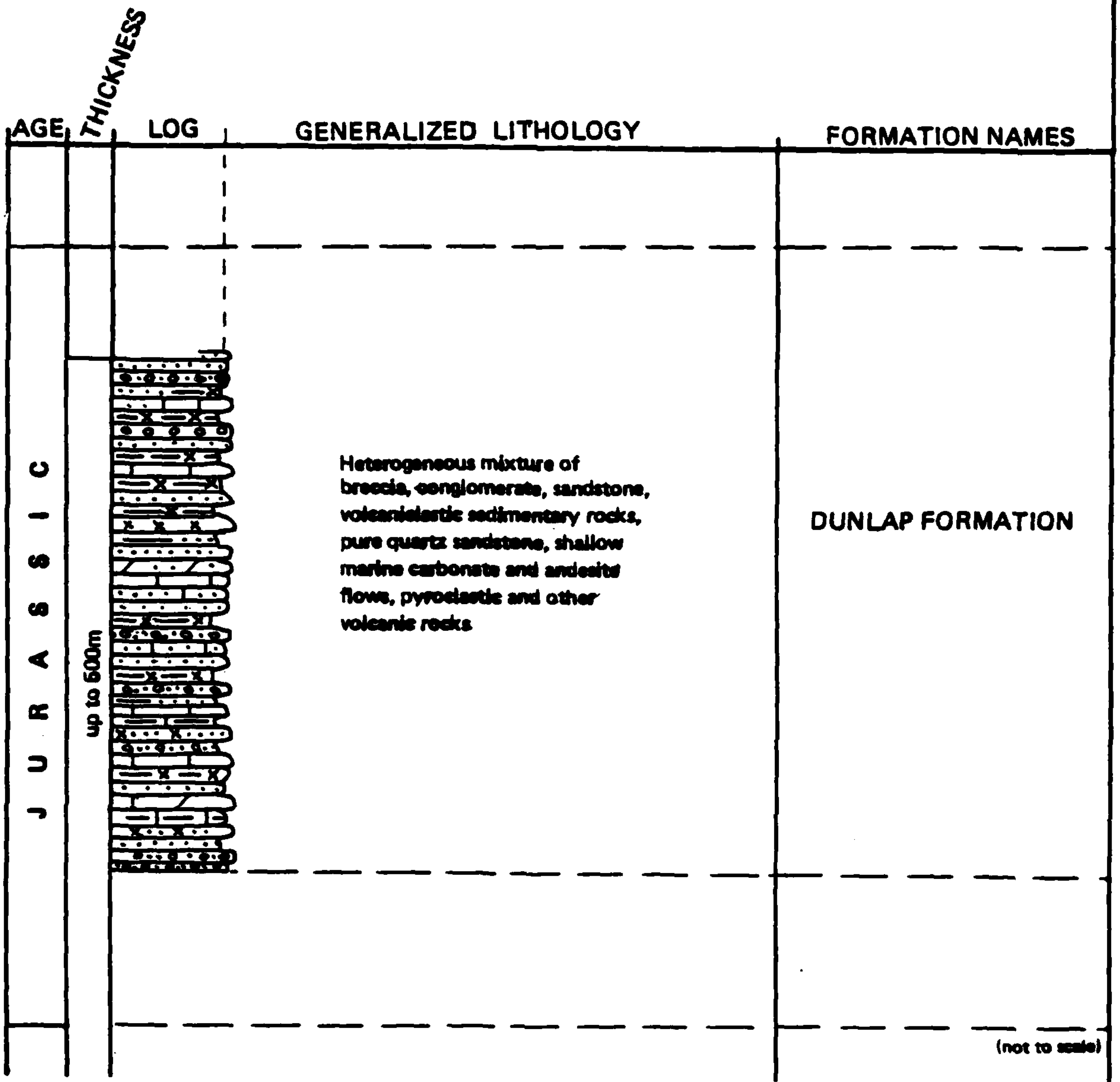
FIGURE 5-15



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JURASSIC ROCK SEQUENCE
NORTH OF TONOPAH

Compiled from Stewart, 1980

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FIGURE 5-18

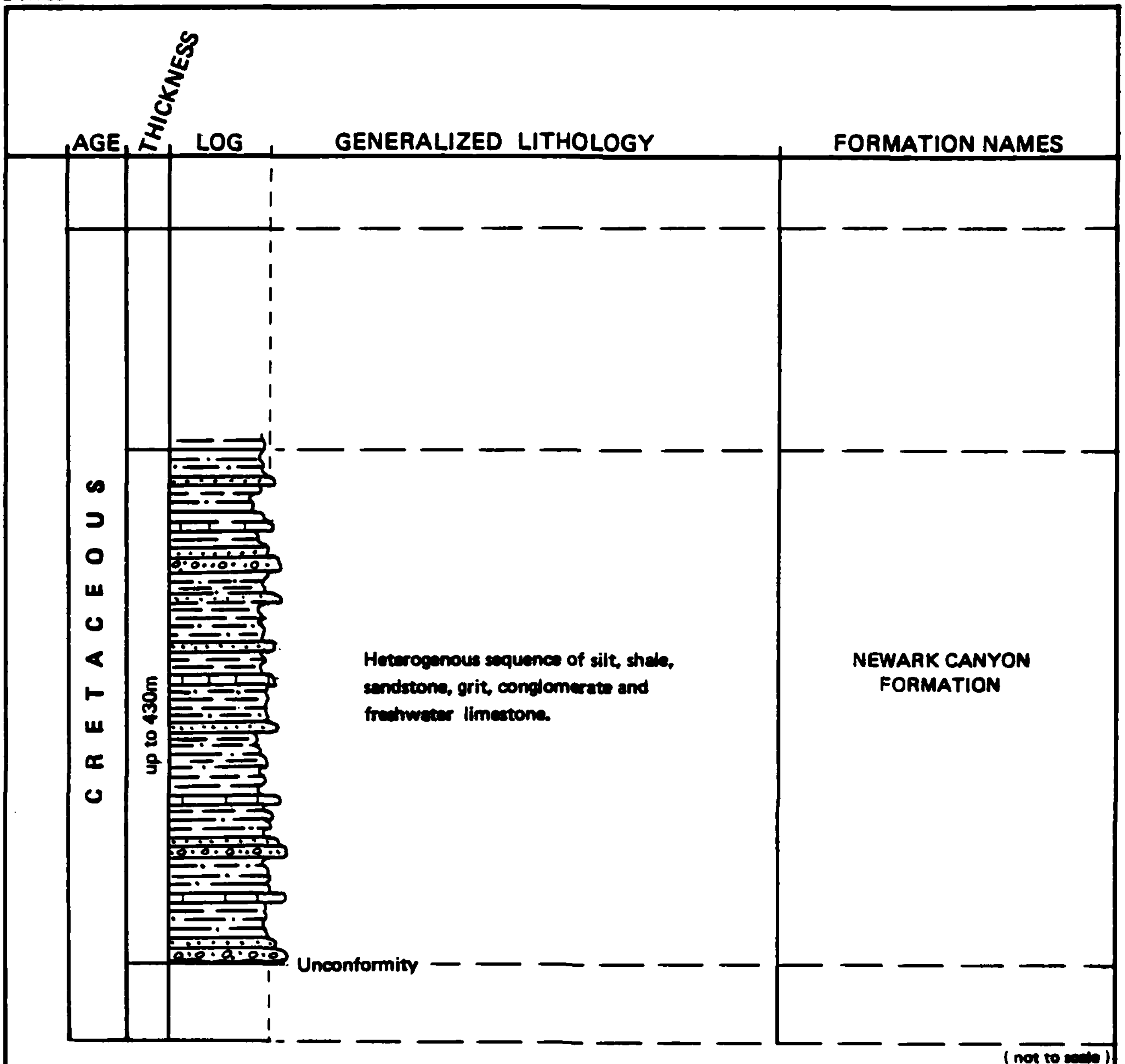
located approximately 12 miles (20 km) northwest of Eureka and 23 miles (38 km) south of Tonopah, granitic rocks of Jurassic age are exposed. Triassic-Jurassic rocks also are identified 6 miles (10 km) north of Tonopah and 9 miles (15 km) west-northwest of Manhattan (T8N,R42E) (Stewart and Carlson, 1978).

C. Cretaceous Period - Cretaceous sedimentary rocks within the study area are only exposed in two localities in the Eureka region, one is 4 miles (7 km) east of Eureka and the other is 25 miles (41 km) west of Eureka. The outcrops consist of a heterogeneous sequence of silt, shale, sandstone, and grit interbedded with conglomerate and freshwater limestone to a maximum thickness of about 1419 feet (430 m) (Figure 5-17). These rocks were deposited in small, shallow basins to a very limited extent.

The Cretaceous plutonic rocks, mostly granodiorite and quartz-monzonite, are exposed in several locations within the study area. All of the known outcrops of these intrusive rocks are shown in Drawing 5. Volcanic rocks of the Cretaceous age do not exist in the study area.

5.1.3.4 Cenozoic Era

The study area remained generally emergent during the Cenozoic era, and no Cenozoic marine sedimentary basins existed in the area. Only a few scattered shallow lakes and marshes existed around Ely and Tonopah during Upper Cenozoic time. The sediments of these lakes consist of a wide variety of continental, fluvial, and lacustrine units containing varying amounts of volcanic debris of contemporaneous origin. As shown in



Compiled from Roberts, Montgomery and Lehner, 1967

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CRETACEOUS ROCK SEQUENCE
IN THE EUREKA REGION

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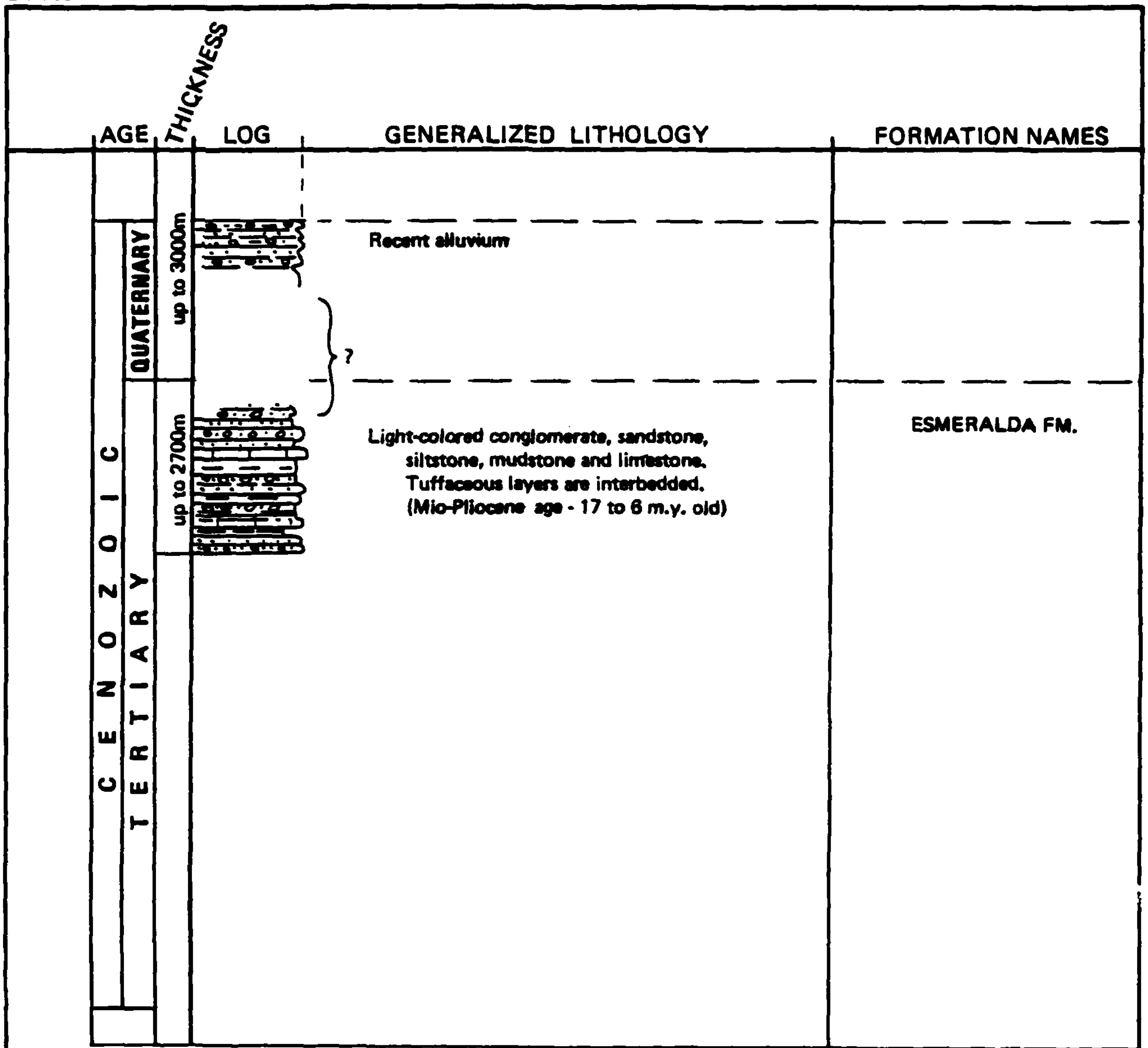
FIGURE 5-17

Figure 5-18, these units are generally light-colored conglomerate, sandstone, siltstone, mudstone, and limestone. In some places, the formations change rapidly in facies from coarse sandstone and conglomerate near mountain ranges to fine siltstone and mudstone away from mountain source areas. Most units contain large amounts of tuffaceous material derived from contemporaneous volcanic deposits, mainly air-fall or water-laid tuff. Lava and ash-flow tuffs locally occur interstratified within the sedimentary sequence. Locally, the thickness of these formations ranges up to 8910 feet (2700 m) (Stewart, 1980).

Tertiary volcanic rocks cover large regions in the study area. As shown in Figure 5-19, the eruption of volcanic rocks occurred mostly during three distinctive periods, six to 17 million years ago, 17 to 34 million years ago, and 34 to 43 million years ago. The older volcanic rocks occur mostly in the north, while the younger volcanic rocks are mainly in the southern parts of the study area. They generally consist of rhyolite, andesite and basaltic flows, welded and nonwelded ash-flow tuff, breccia, pyroclastic, and related rocks.

Quaternary alluvium covers most parts of the study area and consists of semiconsolidated to unconsolidated alluvial fans, valley flats, and playa deposits. Coarse and semiconsolidated material such as fanglomerate and old conglomerate occurs near mountains. Finer unconsolidated alluvial fans, valley flats, and playa deposits occur in the center of the valleys. The



(not to scale)

Compiled from Stewart, 1980

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CENOZOIC SEDIMENTARY ROCK SEQUENCE IN THE STUDY AREA

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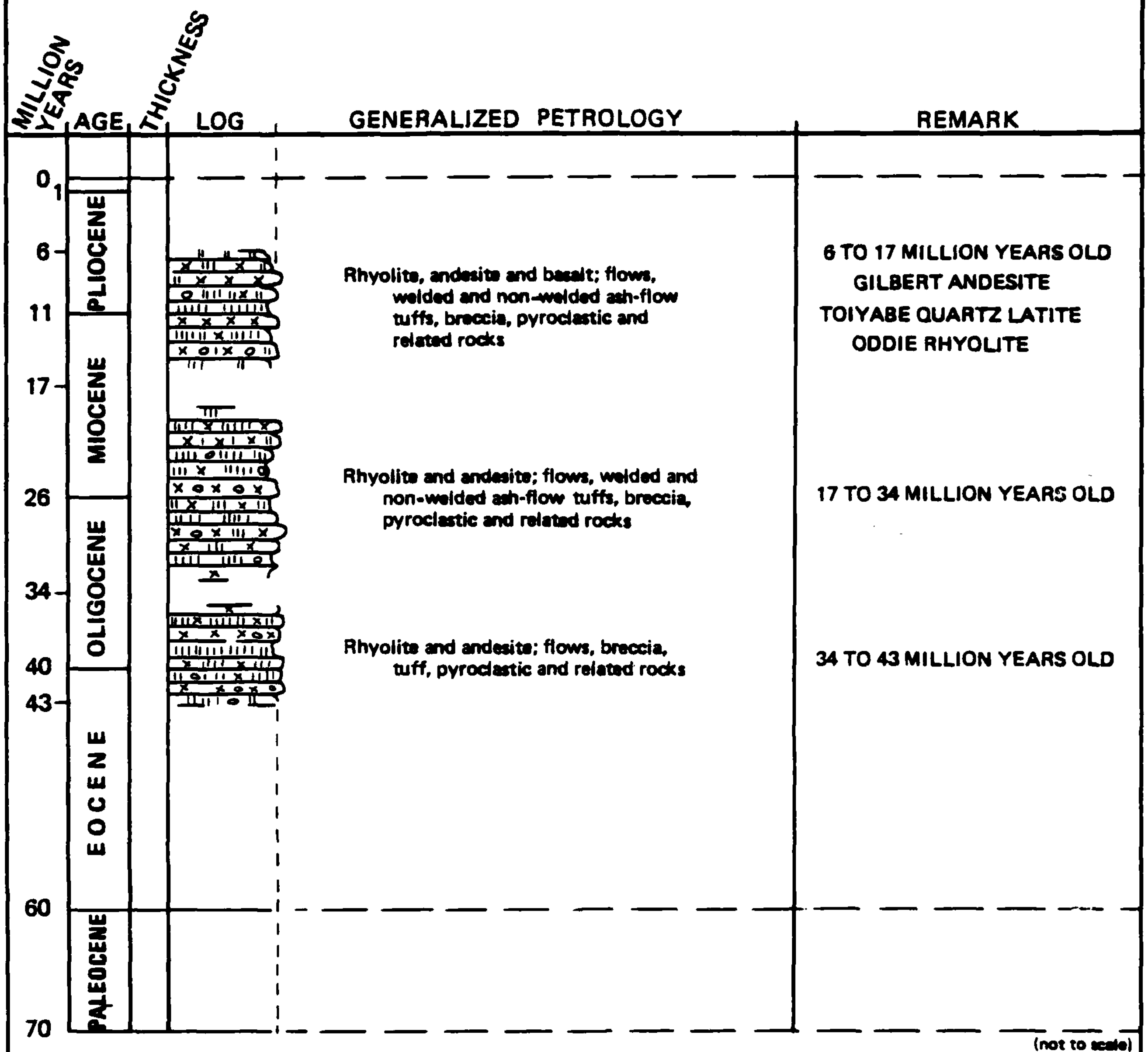
FIGURE 5-18



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TERTIARY VOLCANIC ROCK SEQUENCES IN THE STUDY AREA

Compiled from Stewart, 1980

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FIGURE 5-19

thicknesses of these formations varies considerably from place to place, and, in some of the valleys, the thickness of Quaternary valley fill reaches up to several thousand feet (Hunt, 1967).

5.1.4 Mineral- and Energy-Resource Occurrences

The regional setting of mineral occurrences in the Basin and Range province, including the study area, have been described by many workers. Some of the workers with more important contributions include: Guild (1978), Pajalich and others (1971), Payne and others (1977), Shawe (1978), Shawe and others (1978), and Stager and others (1978).

The sedimentary and igneous rocks and tectonic framework of the Basin and Range province, including the MX Additional Valley Study Area, are interrelated and have contributed to the formation and localization of economic deposits of metals, nonmetallics, oil and gas, and geothermal resources. The interrelationship of a thick, $\pm$33,000-foot ($\pm$10,000-m) sequence of sedimentary rocks deposited in a deep, broad miogeosyncline; major orogenic forces of folding, faulting, and thrusting; and periods of igneous intrusion and later volcanic activity providing a source and concentrating mechanism for minerals has resulted in the creation of favorable environments for ore deposition within the study area. Late Tertiary Basin and Range block faulting has also contributed to the distribution and configuration of metallic and nonmetallic mineral resources.

The principal metals produced in the study area are silver, gold, lead, zinc, copper, tungsten, molybdenum, and mercury. Potential exists for new discoveries of these metals, particularly molybdenum and copper porphyries associated with intrusive rocks and for Carlin-type stratiform gold. Potential also exists for various industrial commodities in diverse geologic environments in both range and valley areas.

The thick sequence of sedimentary rocks in the northern portion of the study area contain many favorable source and host rocks for localization of oil and gas deposits in Paleozoic and Tertiary rocks within the study area. Large post-depositional structural disturbances have created oil and gas traps, and regionally, high heat flow has affected, both positively and negatively, the maturation of contained organic material in the petroleum source sediments. The overall geologic environment is favorable for the discovery of oil and gas deposits in a number of stratigraphic units at many locations within the study area.

Organic rich, metal-bearing marine shales were deposited at different intervals during the Paleozoic era. These shales may produce metals and oil as coproducts under favorable economic technological conditions.

Numerous hot springs within the study area may indicate near-surface sources of heat where water has acted as a transfer agent. Other factors, such as proximity to known geothermal resource areas, magma chambers, and major structures (e.g., calderas, faults, and lineaments), may also indicate that the

study area contains scattered low-to-intermediate-temperature geothermal resources.

5.2 INTERPRETATION OF GEOLOGICAL, GEOPHYSICAL, AND MINERAL OCCURRENCE DATA

As stated in Section 1.2, part of the objective of this study is to identify areas favorable for economic mineral occurrence within the MX Mineral Resources Survey Study Area. This has required the condensation and interpretation of information from hundreds of publications and discussions with representatives from industry, colleges, consultants, and federal and state agencies. Geological, geophysical, and remote sensing data are always subject to a range of interpretations, particularly when applied to mineral deposits. The concepts and principals employed in this report are discussed in detail in the regional Mineral Resources Report (FN-TR-41, Section 5.2), therefore, the reader is referred to that section for additional detailed information. A summary of that section is as follows:

1. Magma is considered to be the original source of all the economic deposits, and igneous rocks are the principal means to carry these mineral deposits to the earth's surface.

2. Volcanic centers and calderas have influence upon structures and mineralization. There are several features of economic interest associated with volcanic centers and calderas.

3. Mineral belts which represent alignment of mineral occurrences or mineralization are an important tool for evaluation of mineral potential of an area. Although the origin of these mineral belts is uncertain, the statistical and geological evidence of their existence is accepted.

4. Lineaments, which are best documented on satellite imagery, represent important deep-seated fault zones (Rowley and others, 1978). They may be loci of intrusive centers, volcanic centers, deep-seated magmas, and their associated hydrothermal systems.

5. Geophysical surveys such as seismic, magnetic, gravity, electrical, and radioactivity have been employed in search for minerals and energy-related sources.

6. Mineral occurrences in an area are related to the structural setting of that area. Remote sensing imagery is a useful tool to identify these structures.

All these items have been considered and utilized in mineral evaluation of the study area. In addition, industrial exploitation and exploration, recent active mining, and past production value from mining districts have also been considered. Table 5-1 shows parameters considered in assigning mineral potential to the MX Additional Valley Mineral Resources Survey Study Area.

Igneous intrusive rocks, volcanic centers, caldera boundary zones, and mineral belts were given parameter weighting. A distinction was made between Tertiary rhyolitic intrusives and Mesozoic and Tertiary granitic plutons. The granitic plutons have a very positive correlation with mineralized areas in the study area and the Tertiary rhyolitic intrusives a lesser correlation, so they are shown as separate parameters in Table 5-1 and are weighted proportionately.

Tertiary rhyolitic tuffs and andesites are shown on Drawing 5 and were considered in compiling the uranium and industrial minerals potential maps but were not given parameter weighting for base- and precious-metals potential. Lineaments are also shown in Drawing 5 and were likewise not given parameter weight in compiling potential maps.

Geophysical data considered and included in this report include aeromagnetic maps and regional gravity studies. Although the

PARAMETER	WEIGHT
Volcanic center	1
Volcanic caldera perimeter area	1
Tertiary rhyolitic intrusive	1
Mesozoic or Tertiary granitic pluton	3
Metal occurrence not included in a mining district (from Larson and others, 1977; Tingley—NBMG, 1980)	1
Positive aeromagnetic anomaly (>10,900 gammas in NE—AVSA*; >11,100 gammas in SW—AVSA*)	1
High positive aeromagnetic anomaly (>11,000 gammas in NE—AVSA*; >11,100 gammas in SW—AVSA*)	2
Industry discovery or active mine	2
Mineral belt	1
Limonitic alteration	1
Favorable host sediment	1
Past production from a mining district (in millions of dollars)	
Less than 1	2
1 to 10	3
10 to 100	4
100 to 1000	5
Greater than 1000	6

*Additional Valley Study Area

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LIST OF PARAMETERS AND THEIR WEIGHT FOR POTENTIAL EVALUATION OF THE STUDY AREA

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TABLE 6-1

regional gravity studies available are included (Drawing 10), no parameter weight was assigned to anomalous areas on this map because of the nondefinitive nature of the anomalies and incomplete coverage. A regional aeromagnetic map is included (Drawing 9), and the shaded anomalous areas, interpreted as possible intrusive centers (Bath, 1976; and Robinson, 1970), were considered in determining base- and precious-metals potential.

Skylab photos printed at approximately 1:250,000 scale were analyzed for anomalous limonitic coloration, and areas of such coloration were mapped as alteration. These mapped areas were then compared to lithologic descriptions on the Nevada State Geologic Map (Stewart and Carlson, 1978), and only in one area north of Mt. Hamilton (T17N, R57E) was the coloration definitely attributable to red-bed sediments. The remaining areas of alteration are shown in Drawing 8 and were considered as a parameter in defining metallic minerals potential in the study area.

That portion of the study area lying in T2N to T2S and R41-43E was not analyzed for color alteration because no true-color Skylab imagery was available for that area. No attempt was made to analyze false-color imagery (LANDSAT) for color alteration.

In order to consider as many parameters as possible in assigning potential to a given area, the parameters listed in Table 5-1 were plotted on a base map and each parameter given a numeric weight (shown adjacent to each parameter in Table 5-1). A 10 mi^2 (25 km^2) grid was then superimposed upon a base map and

a number given to each grid square equal to the sum of all of the *weights of parameters occurring* within that square.

Once parameters were composited and contoured, potentials were assigned as follows:

0 & 1	-	Low
2 & 3	-	Speculative
4 & 5	-	Good
6 & Over	-	High

The resulting potential areas for base and precious metals are shown on Drawing 11 and 12.

5.3 MINERAL COMMODITY OCCURRENCES

Precious and base metals, industrial minerals, or gems have been produced from 41 of the 43 organized mining districts in or adjacent to the Additional Valley Study Area (Chart I). For purposes of this report, an *organized mining district* is one which was named in the literature and for which a generally accepted geographic area is defined by the district name. Such districts may or may not have documented past production, but only those with documented production were given parameter weighting in the assignment of area potentials. Chart 1 of this report was compiled to reduce the volume of this report and to make the data as systematic and accessible as possible. The data presented in Chart 1 are in lieu of a narrative description of each of the mining districts in the study area and represent a departure from the format of the Regional Mineral Survey (FN-TR-41). Base and precious metals are currently being produced from 15 of those districts and one unorganized mining area (Table 5-2). Industrial minerals and/or gems are being

COMPANY NAME	MINE	COMMODITY	MINING DISTRICT	SEC., T-R	OTHER INFORMATION
ESMERALDA COUNTY, NEVADA					
Falcon Exploration Co.[1]	Tonopah Divide Mine	Gold Silver	Divide	Sec. 26, T2N, R42E	6 employees, Open pit Photograph 1A
Goldfield Placer Operation	?	Gold	Goldfield	Sec. 23 T2S, R42E	(Intermittent) Photograph 4B
Margaret Hills, Inc.[2]	Miller's Mill	Gold Silver	?	?	29 employees Mill
Richfield Resources, Inc.[2]	South Klondike	Gold Silver	Klondyke	?	5 employees, Open pit (not operating when field-checked Dec. 1980)
EUREKA COUNTY, NEVADA					
Gold Creek Corp.[1] (Diamond-Silverado, Inc.)	Diamond Mine	Gold Silver	Eureka	Sec. 3, T18N, R53E	18 employees, Underground, leach mill in Newark Valley (Photograph 11A)
Windfall Venture[1]	Windfall Mine	Gold	Eureka	Sec. 2, T18N, R53E	25 employees, Open pit, Heap leach Photographs 12A, 12B, 13A
Mt. Hope Mining Corp.[1]	Mt. Hope Mine	Zinc, lead, copper, gold, silver	Mt. Hope	Sec. 7 & 18 T22N, R52E	Photograph 16
Silver Connor Mines, Inc.[1]	Silver Connor Mine	Silver	Eureka	Sec. 3, T18N, R53E	17 employees, Open pit and Underground, leach mill Photograph 11B

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BASE- AND PRECIOUS-METALS PRODUCING PROPERTIES IN THE STUDY AREA

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PAGE 1 OF 4

TABLE 5-2

COMPANY NAME	MINE	COMMODITY	MINING DISTRICT	SEC., T-R	OTHER INFORMATION
EUREKA COUNTY, NEVADA (Continued)					
TGM Corp.[1]	Mt. Hope Mill	Tungsten Base-precious metals	Mt. Hope	Sec. 18, T22N, R52E	7 employees, Flotation mill Photograph 16
NYE COUNTY, NEVADA					
Anaconda Copper Co.[1]	Nevada Moly Project	Molybdenum	San Antone	T5N, R42E	260 employees, Open pit and mill Photographs 14A, 14B, 15A, 15B
BML Mining Co.[1]	Barcelona Mine	Silver	Barcelona	Sec. 36, T9N, R44E	4 employees, Underground
C.C.P. Industries, Inc.[3]	Shale Pit	Gold	Round Mtn.	T9N, R44E	Photograph 7B
Cordex Exploration[5](?)	Gold Hill Property	Gold	Gold Hill	Sec. 32 T11N, R44E	(Intermittent) Photograph 9B
Cyprus Exploration[1]	Northumberland Mine	Gold	Northumberland	Sec. 18, T13N, R46E	12 employees, Open pit, leach mill (will increase work force when in production) Photograph 10A, 10B
Geo-West Services[2]	Tonopah Extension Mine	Gold Silver	Tonopah		6 employees, Underground (activity not observed during Dec. 1980 field examination)
Gibbons & Read Co.[1] (Leerco)	Manhattan Gulch Placer	Gold	Manhattan	Sec. 19, T8N, R44E	4000 yd/day operation to begin May, 1981, Photograph 7A

BASE- AND PRECIOUS-METALS PRODUCING PROPERTIES IN THE STUDY AREA

COMPANY NAME	MINE	COMMODITY	MINING DISTRICT	SEC., T-R	OTHER INFORMATION
NYE COUNTY, NEVADA (Continued)					
Houston International Mineral Corp.[1]	Manhattan Mine & Mill	Gold	Manhattan	Sec. 20, T8N, R44E	27 employees, Open pit Photographs 6A, 6B
James Pauley[1]	Nellie Gray Patent	Gold	Manhattan	Sec. 20, T8N, R44E	2 employees, Underground (Intermittent)
Manhattan Milling Inc.[1]	April Fool Mine & Manhattan Mill	Gold Silver	Manhattan	Sec. 20, T8N, R44E	4 employees, Open pit Cyanide mill
Smokey Valley Mining Co.[1]	Round Mtn. Operation	Gold	Round Mtn.	Sec. 18, T10N, R44E	150 employees, Open pit Photographs 8A, 8B, 9A
W. E. Vining Co.[2]	Manhattan Project	Gold Silver	Manhattan	?	10 employees
WHITE PINE COUNTY, NEVADA					
Amselco Minerals, Inc.[1]	Alligator Ridge Gold Mine	Gold	Alligator Ridge, Unorganized	Sec. 2, T22N, R57E	18 employees (increasing with full production), Open pit, leach mill Photographs 3A, 3B
Cherry Creek Mining & Milling[1]	Teacup or Fillmore Mine	Silver	Cherry Creek	Sec. 24, T24N, R62E	3 employees, Open pit, leach mill Photograph 1B

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BASE- AND PRECIOUS-METALS PRODUCING PROPERTIES IN THE STUDY AREA

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TABLE 5-2

COMPANY NAME	MINE	COMMODITY	MINING DISTRICT	SEC., T-R	OTHER INFORMATION
WHITE PINE COUNTY, NEVADA (Continued)					
Gold Creek Corp.[1]	Bay State Mine	Silver	Newark	Sec. 9, T19N, R55E	5 employees, Underground (not operating when field checked Dec., 1980)
Gold Creek Corp.[1]	Treasure Hill Mine	Silver Lead	White Pine	Sec. 19, T16N, R58E	34 employees, Open pit, leach mill (seasonal operation) Photograph 13B

[1]Nevada Industrial Commission, 1980, Directory of Nevada Mine Operations active during calendar year 1979 (and draft additions for 1980): Compiled by the staff of the State Inspector of Mines, Francis E. DuBois, III, State of Nevada.

[2]Mine Safety and Health Administration, 1980, Metal/Nonmetal file reference: Dept. of Labor, processing date, August 5, 1980.

[3]Payne, A.L. and Papke, K.G., 1977, Active Mines and Oil fields in Nevada: Nevada Bureau Mines and Geology Map 55, Scale 1:1,000,000.

[4]Tingley, J.V., 1980, Preliminary CRIB report form: Nev. Bu. Mines and Geol.

[5]Ertec Rocky Mtn. field examination, 1980.

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BASE- AND PRECIOUS-METALS PRODUCING PROPERTIES IN THE STUDY AREA

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TABLE 5-2

produced from three districts and one unorganized mining area (see Table 5-5, page 103). Twenty-four oil and gas exploratory wells have been drilled in the study area as of March 1980 with shows in 10 wells (see Table 5-6, page 115). Noncommercial occurrences of uranium, coal, oil shale, and geothermal resources are also present.

5.3.1 Precious Metals

Significant production of gold (Au), silver (Ag), and mercury (Hg) has come from 37 of the 43 mining districts in and adjacent to the study area. The location, geology, and production history of the districts (for precious- and base-metal production) are summarized on Chart 1.

For the detailed information regarding type of deposits, geologic environments, and current exploration status of the precious metals in central Nevada including the study area, refer to the MX Mineral Resources Survey Study Area Report (FN-TR-41), Section 5-3.

5.3.1.1 Distribution and Production

Historic gold production came principally from mines located west of the Roberts Mountains thrust in the Antler Orogenic Belt. Large open-pit gold mines are presently operating within this belt at Manhattan, Round Mountain, and Northumberland. Exploration for additional deposits, including disseminated gold deposits in altered rhyolitic units within the belt, is intense.

Silver and mercury were recovered as coproducts with gold in many districts in the Antler Orogenic Belt, and several districts, notably Belmont, Manhattan, Horse Canyon, and Jefferson Canyon, produced mercury as the primary commodity of some deposits. Silver yielded the greatest value in the extensively developed Tonopah and Belmont districts and is currently being mined from a disseminated near-surface deposit in the Divide District (Falcon Exploration Co., personal communication, 1980) (Photograph 1A).

East of the Antler Orogenic Belt, in Nevada's base-metal metallogenic province, the character of the ore deposits changes, and silver-lead mineralization is historically the dominant type of deposit produced. The major districts of Eureka and White Pine are typical of this province. The Egan Range, on the eastern edge of the study area, has many types of deposits, including silver-lead at Cherry Creek (Photograph 1B), gold at south Cherry Creek and in the Hunter/Granite districts, and the huge porphyry copper deposits in the Robinson District (see Photographs 2A, B).

The relatively recent development of large, low-grade, disseminated gold deposits in Nevada has added a new dimension to the character of precious-metal deposits being sought in the eastern part of the study area. At Alligator Ridge (T22N, R57E), Amselco has begun mining disseminated gold from a deposit in the Devonian Pilot Shale (Photographs 3A, B). Reserves are estimated to be 5 million tons, averaging 0.12 ounces of gold

A – VIEW SW – FALCON EXPLORATION'S SILVER MINE IN THE DIVIDE DISTRICT WITH MONTEZUMA VALLEY IN THE CENTER BACKGROUND.

B – VIEW W – OLD CHERRY CREEK MILL WITH NEW HEAP LEACH PADS UNDER CONSTRUCTION.

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	PHOTOGRAPH 1

A – VIEW E – KENNECOTT COPPER CORP.'S CURRENTLY INACTIVE PORPHYRY COPPER MINES IN THE ROBINSON DISTRICT AT RUTH, NEVADA

B – VIEW NNE – LARGE DUMPS OF THE KENNECOTT COPPER CORP. OPERATIONS IN THE ROBINSON DISTRICT.

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PHOTOGRAPH 2

A VIEW N AMSELCO'S ALLIGATOR RIDGE GOLD MINE. MILL AND SETTLING PONDS (FOREGROUND). LEACH PADS (CENTER), PIT AND DUMPS (REAR).

B VIEW W AMSELCO'S ALLIGATOR RIDGE MILL FACILITIES.

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PHOTOGRAPH 3

per ton, and exploration drilling is continuing north and south of this deposit (Amselco, personal communication, 1980). In addition to the Pilot Shale, Amselco and other companies are exploring for disseminated gold in other similar formations in the study area. Table 5-3 is a list of units which have lithologies ranging from argillaceous to dolomitic-brecciated carbonates to calcareous siltstones/shales, all favorable host units for disseminated gold deposits. Silicification and argillization of the host sediment is common to nearly all of the disseminated gold deposits in Nevada, and geochemical sampling of such areas within favorable host units is the most common and prudent form of exploration to date.

The units shown in Table 5-3 were plotted in Drawing 7 and were considered as a parameter in compiling the precious-metals-potential map (Drawing II). From the distribution of known occurrences, it appears that the most favorable units are shales with calcareous, silty facies rather than the silty, argillaceous facies in carbonate units, but both are potential hosts.

5.3.1.2 Review of Potential

In addition to disseminated gold exploration, virtually all of the districts in the seven-valley study area are being re-examined in light of the recent phenomenal rise in precious metals prices. Noranda (written communication, 1980) is engaged in a detailed re-appraisal of the Goldfield District (Photograph 4A) and reports favorable results. Small-scale placer operations are currently producing in that district (Photograph 4B),

PERIOD	FORMATION
CAMBRIAN	Emigrant Springs Fm. Windfall Fm. Secret Canyon Shale Lincoln Peak Fm.
ORDOVICIAN	Pogonip Group Fish Haven Dolomite *Vinini Fm.
SILURIAN	*Roberts Mountains Fm.
DEVONIAN-MISSISSIPPIAN	*Pilot Shale Guilmette Fm. Rabbit Hills Fm. Eleana Fm. Joana Limestone *Chainman Shale/Diamond Peak Fm.
PERMIAN	Gerster Limestone (Park City Group)

*Known disseminated gold occurrences in these units

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FAVORABLE HOST UNITS FOR
DISSEMINATED GOLD DEPOSITS

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TABLE 5-3

A – VIEW NE – NUMEROUS HEADFRAMES AND DUMPS IN THE CENTRAL GOLDFIELD DISTRICT.

B – AERIAL VIEW – SMALL GOLD PLACER OPERATION IN MONTEZUMA VALLEY JUST NORTH OF GOLDFIELD.

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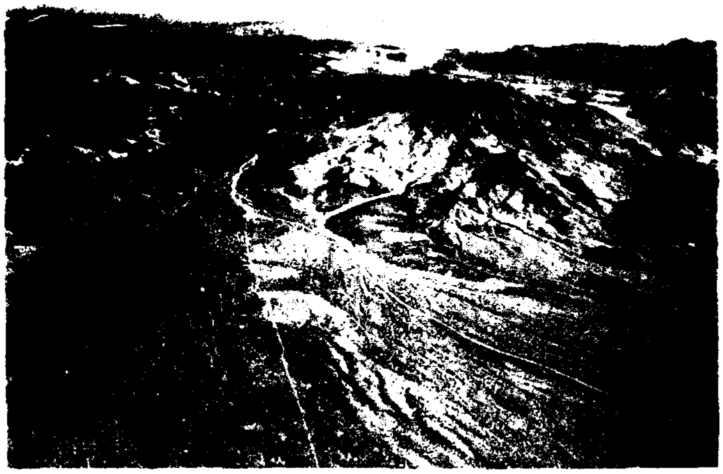
PHOTOGRAPH 4	

and most of the potential placer ground in T2S, R42E has been recently staked (Ertec Rocky Mountain, 1980, field examination). The potential for additional production from this district is high.

North of Goldfield, exploration is ongoing in the San Antonio Mountains all the way to T6N, and much of this range has been recently restaked. Falcon Exploration, operating a surface silver mine in the Divide District (Photograph 1A), has staked mill site claims in Montezuma Valley (Sec. 9 & 16, T1N, R42E) and was drilling water test wells at that site when visited by Ertec Western in December 1980. Phelps Dodge Corporation has also acquired a large claim block south and east of Falcon's property in the Divide District (Ertec Rocky Mountain, 1980, field examination).

Houston International, Falcon, Treasure Hill Mines, and possibly others are drilling and exploring prospects in the Klondyke District (Photographs 5A, B). Treasure Hill reports drill intercepts of 40 ounces per ton silver and is pursuing near-term development of this property (Treasure Hill Mines, Inc., personal communication, 1980). Precious-metal (and base-metal) exploration is also ongoing in the Lone Mountain-Weepah District on the opposite side of Montezuma Valley.

At Manhattan, Houston International Minerals Corp. is operating a 1000-ton-per-day gold mine (Photographs 6A, B), and Leerco, a Salt Lake City-based firm, plans to begin gold-placer operations in May 1981. Leerco anticipates an initial 4000-yard-per-day



A – VIEW E – NORTH END OF THE KLONDYKE DISTRICT (CENTER-RIGHT) WITH DISCOVERY PITS FOR PLACER CLAIMS EXTENDING WEST INTO MONTEZUMA VALLEY.

B – VIEW NE SOUTH END OF THE KLONDYKE DISTRICT (LEFT CENTER) WITH PLACER CLAIMS EXTENDING SOUTH AND WEST INTO THE VALLEY.

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PHOTOGRAPH 5

A – VIEW S NORTH PIT (FOREGROUND) OF THE HOUSTON INTERNATIONAL GOLD MINE AT MANHATTAN. MILL AND TAILINGS POND IN THE BACKGROUND.

B VIEW W HOUSTON INTERNATIONAL'S MANHATTAN GOLD MINE (FOREGROUND) WITH MANHATTAN GULCH RUNNING FROM THE LOWER RIGHT TO UPPER LEFT AND EMPTYING INTO BIG SMOKY VALLEY.

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PHOTOGRAPH 6

operation, expanding to 10,000 yards per day at full capacity (written communication, Leerco, 1980). This placer operation would eventually encompass most of the alluvial gravel in the west half of T8N, R43E (Photograph 7A). This area and the Manhattan District proper have high mineral potential.

Just north of Manhattan, at Round Mountain, Smoky Valley Mining Company is operating the large Round Mountain open-pit gold mine (Photographs 8A, B, 9A). Recent drilling has extended this deposit over a mile south and west of the present mine (Smoky Valley Mining Company, personal communication, 1980). Future expansion of the mine will necessitate a new, expanded mill with a projected capacity of up to 10 million tons per year. Feasibility studies for that expansion are currently in progress, and if it is built, the mill, waste disposal, and tailings will occupy most of T10N, R43E in Big Smoky Valley. Pit expansion and placer potential west of the mine give most of this area high precious-metal potential. The placer potential of the Round Mountain to Manhattan portion of Big Smoky Valley is included in the precious-metal potential shown in Drawing 11 and accounts for that portion of the potential extending westward without change across the 2000-foot (600-m) depth line.

High precious-metal potential also exists at Gold Hill (Photograph 9B), Northumberland (Photographs 10A, B), and several portions of the Toquima, Toiyabe, and Monitor ranges in the Antler Orogenic Belt.

A – VIEW SSW BIG SMOKY VALLEY NEAR MANHATTAN. SPOILS PILES OF MANHATTAN GULCH PLACER OPERATIONS (CENTER) IN THE AREA OF LEERCO'S PROPOSED NEW PLACER OPERATIONS.

B VIEW NE SHALE PIT GOLD MINE OPERATIONS ON THE EAST SIDE OF BIG SMOKY VALLEY 5 MILES SOUTH OF ROUND MOUNTAIN.

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PHOTOGRAPH 7

A – VIEW E · SMOKY VALLEY MINING CO.'S ROUND MOUNTAIN GOLD MINE WITH THE TOQUIMA RANGE IN THE BACKGROUND.

B – VIEW NE ROUND MOUNTAIN AREA WITH DRILL SITES MARKING FUTURE PIT EXPANSION SOUTH AND WEST OF THE MINE IN BIG SMOKY VALLEY.

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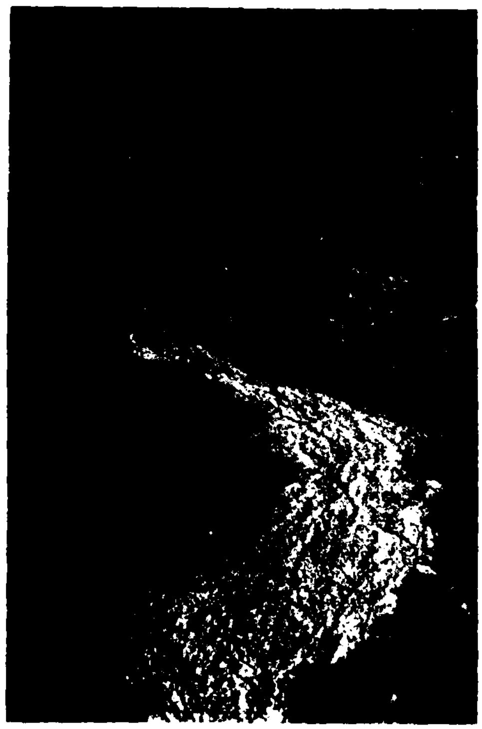
PHOTOGRAPH 8

A - VIEW W — OPEN PITS AT ROUND MOUNTAIN (FOREGROUND), BIG SMOKY VALLEY (CENTER), AND TOIYABE RANGE (BACKGROUND).



B VIEW E GOLD HILL MINE AND DISTRICT EAST SIDE OF BIG SMOKY VALLEY.

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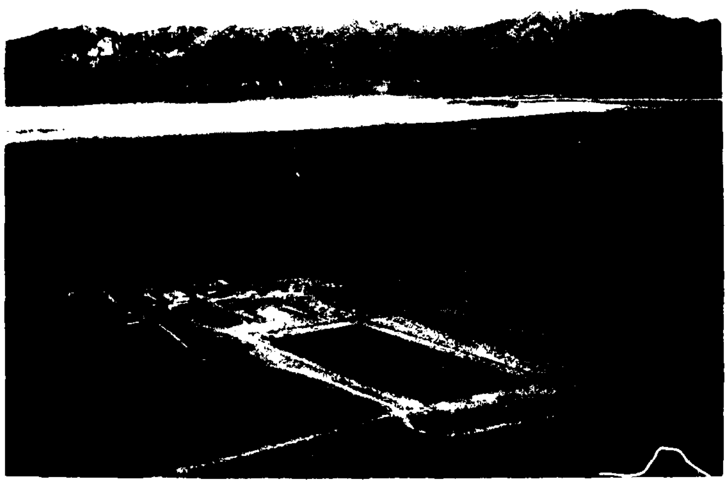
PHOTOGRAPH 9

A – VIEW NW – CYPRUS MINES' NORTHUMBERLAND GOLD PROPERTY, TOQUIMA RANGE. CRUSHING PLANT (CENTER-RIGHT), DRILL ROADS AND INITIAL PIT (CENTER-LEFT), AND OLD GOLD PITS (LOWER-CENTER).



B – VIEW W CYPRUS MINE'S LEACH PADS AND MILL FACILITIES IN BIG SMOKY VALLEY.

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	PHOTOGRAPH 10

In the eastern portion of the study area, gold and silver production by Diamond Silverado Mines (Photograph 11A, B), Windfall Ventures (Photographs 12A, B, 13A), the currently inactive Ruby Hill Project of Hecla Mining Company (Photograph 2, FN-TR-41 Report), and future development from innumerable other exploration programs gives the Eureka District high potential. High potential is also assigned to most of the Pinto District where Diamond Silverado, Inc. is mining silver and has a heap leach mill operating (Photograph 11B).

Treasure Hill mines is seasonally operating a heap leach mill and silver mines near the old townsite of Hamilton in the White Pine District (Photograph 13B), and all of this district is being held under claim and being actively explored. This district has high potential for precious (and base) metals.

The unorganized mining area around Alligator Ridge has high precious metal potential resulting from Amselco's mine (Photographs 3A, B) and new discoveries. Much of the Egan Range, with its past production and active current exploration, also has high potential. The balance of the study area has been rated as having high-, good-, speculative-, or low-precious metals potential according to the parameters weighting system shown in Table 5-1. Because precious- and base-metal potential has been separated in the Additional Valley Study Area, some minor changes have been made in the parameters used and their relative weights, but these changes are self-explanatory and apparent in Table 5-1. The mining districts were divided into those with

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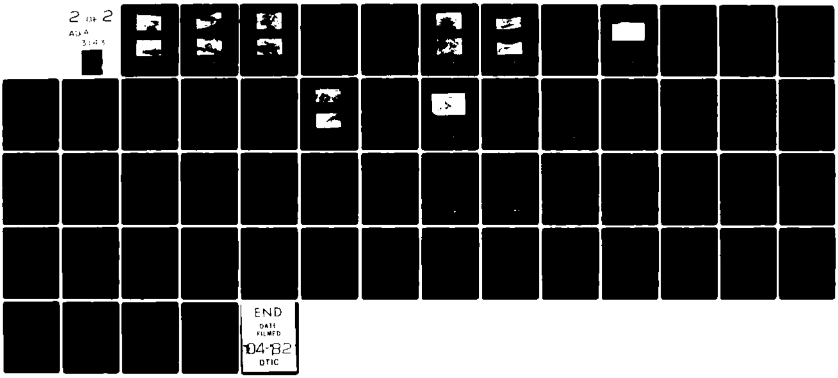
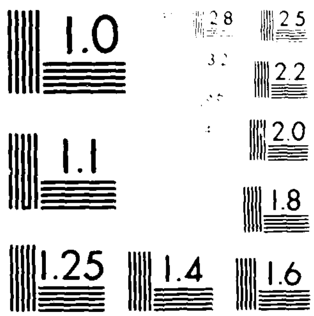
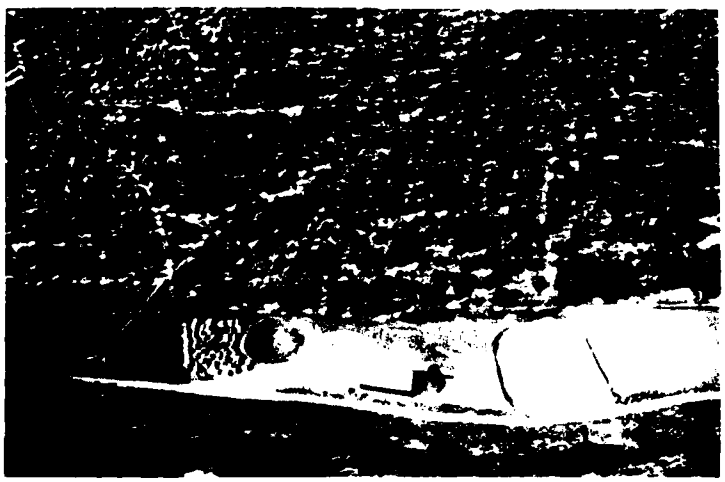




MICROCOPY RESOLUTION TEST CHART

A – VIEW WNW – DIAMOND SILVERADO MINES' SILVER LEACH MILL IN THE PINTO DISTRICT, WEST SIDE OF NEWARK VALLEY.



B – AERIAL VIEW – SILVER CONNOR MINES' LEACH MILL IN SECRET CANYON, EUREKA DISTRICT (UNDER CONSTRUCTION)

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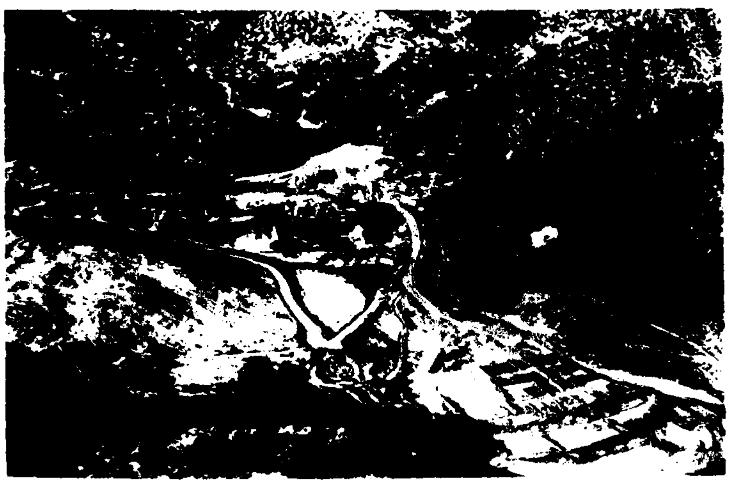
PHOTOGRAPH 11

A VIEW S OPEN PIT AT WINDFALL VENTURES' GOLD MINE, EUREKA DISTRICT.



B VIEW W WINDFALL VENTURES' GOLD MINE (CENTER-LEFT) AND LEACH PADS (LOWER-RIGHT) IN THE EUREKA DISTRICT.

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PHOTOGRAPH 12

A AERIAL VIEW WINDFALL VENTURES' LEACH PADS AND MILL FACILITY, EUREKA DISTRICT.

B AERIAL VIEW LEACH PADS AND MILL FACILITY OF TREASURE HILL MINES, INC. AT MT. HAMILTON IN THE WHITE PINE DISTRICT

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PHOTOGRAPH 13

production of primarily base metals, precious metals, or both, and were used as parameters in Drawings 11 and 12 according to their primary commodities.

5.3.2 Base/Ferrous Metals

The base/ferrous metals considered in this report include copper, lead, zinc, tungsten, and molybdenum. In addition, the occurrence of nickel, cobalt, and palladium in serpentinites south of Manhattan is noted, although no potential has been assigned to that occurrence. Minor amounts of antimony, arsenic, and bismuth have also been produced from various districts in the study area, but no potential has been assigned to these areas because of that production. Occurrences of beryllium, manganese, iron, and various other metals were noted in the literature search, but since there has been no production and no commercial deposits of these commodities known in the study area, no potential for their development has been assigned.

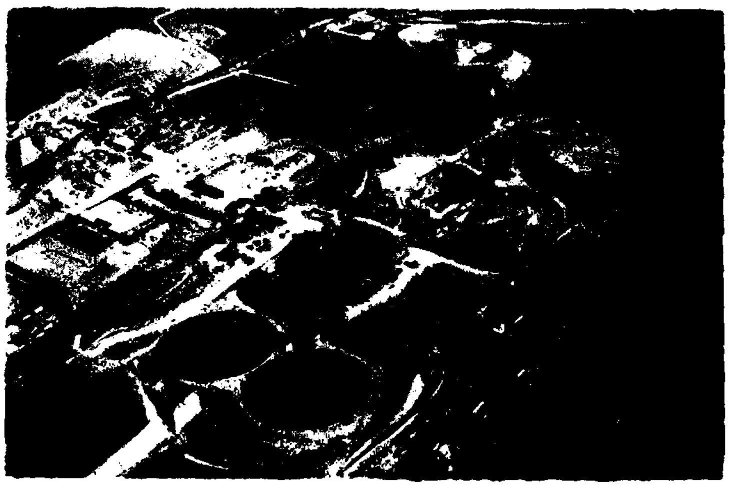
5.3.2.1 Distribution and Production

Chart 1 summarizes the base-metal-producing districts in the study area. It can be seen that in the area south and west of the Antelope Peak Caldera, only the Spencer Hot Springs and Twin River districts had major production of a base-metal commodity, and that was tungsten. Base metals were produced as a minor commodity in several other districts in this part of the study area but were greatly overshadowed by the precious-metal values in those districts.

Currently, however, the largest mine in the study area, the Hall Mine, is being developed by the Anaconda Company in the San Antone District (Photographs 14A, B, 15A, B). Anaconda estimates ore reserves of 140 million tons with an average grade of 0.13 percent molybdenum sulfide (MoS_2) and 40 million tons of recoverable copper ore (Anaconda Company, personal communication, 1980). The mine and mill are under construction and due to begin production in late 1981 with production scheduled at 20,000 tons per day. Once it is producing, Anaconda has potential deposits currently being evaluated in nearby districts which may be developed and shipped to the Hall Mine for milling. Mine life of the Hall Mine is expected to be 22 years, but mill life could be longer if additional deposits are milled at Hall. Land needs in Big Smoky Valley for tailings disposal can be expected to increase in the future if additional deposits are milled at the Hall facility. The area of high base-metal potential on Drawing 12 extending into Big Smoky Valley at the Hall Mine includes the waste and tailings disposal areas of the mine irrespective of depth-to-bedrock consideration.

In the southwest part of the study area, additional areas of porphyry molybdenum potential exist in the San Antonio Mountains south of Hall where Phelps Dodge Corp. is prospecting a claim block (Anaconda Company, personal communication, 1980), in the Lone Mountain-Weepah District (Tingley, 1980b), and in the Barcelona District near Spanish Peak where Phelps Dodge, U.S. Borax Company, and others have active claim blocks (Ertec Rocky Mountain, field examination, 1980).

A – VIEW NE – ANACONDA'S HALL MOLYBDENUM MINE ON THE EAST SIDE OF BIG SMOKY VALLEY, SAN ANTONE DISTRICT.



B – AERIAL VIEW MILL, OFFICE, AND SUPPORT FACILITIES AT THE HALL MINE.

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PHOTOGRAPH 14

A – VIEW SW – ANACONDA'S HALL MINE (FOREGROUND) WITH 15 YD. SHOVELS AND 120 TON HAUL TRUCKS IN THE PIT. BIG SMOKY VALLEY IN THE BACKGROUND.

B – VIEW N – HALL MINE (CENTER-RIGHT) AND TAILINGS DAM IN BIG SMOKY VALLEY (UNDER CONSTRUCTION).

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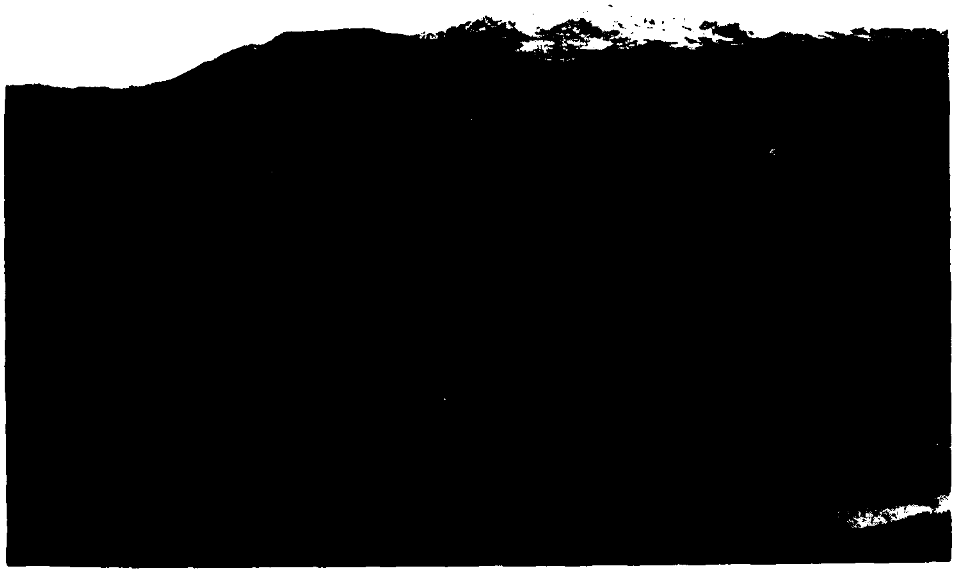
PHOTOGRAPH 15

In the northern portion of the study area north and east of the Antelope Peak Caldera, many more mining districts produced base metals as a principal commodity. Of these districts, Mount Hope, Eureka, White Pine, and Cherry Creek have recorded production exceeding one million dollars, and the Robinson District just east of the study area produced over one billion dollars, primarily in copper.

Current exploration for base-metal porphyry deposits is ongoing in several districts in the northern portion of the study area. Exxon Minerals is evaluating possible molybdenum porphyry deposits in the Roberts District and southeast of the White Pine District (T15N, R59E), and they are drilling a moly porphyry discovery at Mount Hope (Photograph 16). Initial results at Mount Hope indicate a molybdenum ore body of 450 to 950 million tons with grades of 0.13 percent to 0.32 percent MoS_2 lying between 50 and 3000 feet (15 and 910 m) deep. Additional drilling is scheduled for 1981 (Exxon Minerals Company, written communication, 1981).

Exxon is also planning to drill a deep test hole on a geophysical anomaly in the Butte Valley that is believed to be caused by a deep-seated intrusive. This geophysical anomaly and the geology of the area surrounding Butte Valley give this area a good base-metal potential in the area of the Exxon claim block as seen in Drawing 12.

Other companies actively prospecting for molybdenum deposits include Phillips Petroleum's Mineral Exploration group drilling



VIEW NW – MT. HOPE DISTRICT WITH MT. HOPE MINE AND MILL (LOWER CENTER). EXXON MINERALS PORPHYRY MOLYBDENUM PROSPECT INCLUDES ALL OF MT. HOPE AND THE LOW TIMBERED HILL IN THE CENTER RIGHT BACKGROUND.

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PHOTOGRAPH 16

adjacent to the Monte Cristo Stock in the White Pine District and Union Carbide Corp. in the same area. Active exploration for porphyry, as well as vein and replacement base-metal deposits, is taking place in virtually every range and mining district in the northern part of the study area.

5.3.2.2 Review of Potential

Base-metal potential can be divided into porphyry potential (molybdenum and copper) and vein-lode-replacement-type potential deposits of composite mineralization (lead-zinc-copper and precious metals). Tungsten can and does occur in both types of deposits in the study area.

Porphyry potential is high in the Lone Mountain-Weepah, Royston, San Antone, Barcelona, Roberts, Mount Hope, and White Pine districts and good in the Exxon exploration area of Butte Valley. Shawe (1977) also suggests undiscovered porphyry potential in the western Toquima Range between the Manhattan and Round Mountain districts. The regional aeromagnetic map (Drawing 9) suggests some areas of possible buried intrusives (i.e., central Monitor Valley, Pancake Range) that have not been explored for porphyry mineralization but show striking similarity to anomalies associated with known intrusives.

All of the districts in the northern portion of the study area are currently being explored and reevaluated. Those districts in the Base Metals Metallogenic Province are the most likely to have significant new production of base metals. Those areas with high base metal-potential include the Eureka, White Pine,

and Cherry Creek districts in the north and the Lone Mountain-Weepah, Tonopah, and Barcelona districts in the west. Part of the Jett District in the Toiyabe Range also has high potential for base metals, especially tungsten. Table 5-4 lists those units favorable for the development of base-metal replacement deposits.

As with precious metals, the entire study area was evaluated for base-metal potential by constructing and contouring a numeric grid based on a composite of the weighted parameters shown in Table 5-1. The resulting base metals potential map for the study area is shown in Drawing 12.

5.3.3 Uranium

There has been no recorded uranium production in the MX Additional Valley Study Area, even though over 30 known radioactive occurrences or clusters of occurrences are recognized. For the most part, these occurrences are located in a generally north-south belt extending from Tonopah to the Northumberland Caldera in and adjacent to the San Antonio and Toquima mountain ranges (Drawing 14).

5.3.3.1 Occurrences and Distribution

To the east and north of the Antelope Peak Caldera (T18N, R49E), there are three known uranium occurrences, one in the Eureka Mining District (T18N, R53E) and two in the Egan Range (T21-22N, R62E). The Eureka occurrence and the southernmost Egan Range occurrence are scattered uranium minerals in fractured or

PERIOD	FORMATION	
PRECAMBRIAN – CAMBRIAN	Reed Dolomite Campito Fm. Harkless Fm. Pole Canyon Limestone El Dorado Dolomite Windfall Fm.	Deep Spring Fm. Poleta Fm. Mule Spring Limestone Lincoln Peak Fm. Hamburg Dolomite
ORDOVICIAN	Hanson Creek Fm. Vinini Fm.	Eureka Quartzite Pogonip Group
SILURIAN	Lone Mountain Dolomite Roberts Mountains Fm.	
DEVONIAN	Nevada Fm.	
MISSISSIPPIAN	Joana Limestone	
PENNSYLVANIAN	Ely Limestone	
PERMIAN	Riepe Spring Limestone Garden Valley Fm.	

Some of the above formations were given parameter weighting only in specific mining districts.

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BASE-METAL REPLACEMENT DEPOSITS

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TABLE 5-4

sheared Paleozoic sediments associated with silver-lead mineralization. The other Egan Range occurrence has scattered autunite crystals on fractured faces in what is reported to be a Tertiary latite (?) (Garside, 1973).

Three additional occurrences lie just outside the study area. Two are associated with base/precious metal mines near Bald Mountain (T23N, R63E) and the third is the slightly radioactive Cherry Creek Hot Spring in the Steptoe Valley (T23N, R63E) (Garside, 1973).

Numerous uranium occurrences have been described in the Toquima Range (Garside, 1973; Larson and others, 1977; Lovering, 1954; and Cohenour, 1980). They include uranium in Paleozoic fractured metasediments near the Northumberland Caldera, in fractured and altered tuffs in and adjacent to the Mt. Jefferson Caldera and at Round Mountain, and in fractures and faults in the Mesozoic granite near Round Mountain and Belmont. Two additional radioactive occurrences in the Tertiary tuffs of the Peavine Caldera (Larson and others, 1977) have been staked and are being prospected by Federal Resources Corp. in the area of T8N, R41-42E (Ertec Rocky Mountain, field examination, 1980).

Thirty-five separate occurrences of anomalous radioactivity or uranium have been identified in an 8-mile (13-km) long area on the west flank of the San Antonio Mountains just west of Tonopah (Larson and others, 1977). Most of these occurrences are in rhyolitic tuffs or interbedded tuffaceous siltstones of

the Tertiary Siebert Tuff. A phosphate-rich lake bed facies of this unit has been shown to contain up to 0.12 percent U_3O_8 in select samples (Cohenour, 1980). Such values are significantly higher than those postulated by Bell (1960).

5.3.3.2 Types of Occurrences and Geologic Environments

Section 5.3.3.2 of the FN-TR-41 report discusses in detail the types of occurrence and environments of uranium deposition likely to be found in the study area, and no changes or additions are offered herein. The great thicknesses of Tertiary rhyolitic welded and nonwelded tuffs adjacent to Big Smoky, Monitor, and Little Fish Lake valleys make these areas likely depositional basins for the volcanically derived uranium deposits described in Section 5.3.3.2, including the relatively newly recognized environment of uranium in zeolites (Basinsky and Larson, 1979). Big Smoky Valley has additional potential from arkosic sediments and accompanying uranium derived from the many Tertiary and Mesozoic granitic intrusives bordering the valley.

5.3.3.3 Current Exploration Status

The majority of uranium exploration activity in the study area is located in and adjacent to Big Smoky Valley. Noranda Exploration, Inc. has a large uranium claim block covering the Northumberland Caldera area on the study area boundary (T12N, R44-45E) (Noranda Exploration, personal communication, 1980); Federal Resources is investigating the tuffaceous units in the Peavine Caldera (T8N, R41-42E). Other companies have claims

covering the Siebert Tuff occurrences west of Tonopah and in the Jefferson Canyon area east of Round Mountain (T10N, R44-45E) (Ertec Rocky Mountain, field examination, 1980).

5.3.3.4 Review of Potential

Because of the absence of past production of uranium within the study area, the highest potential category assigned to any area is speculative. Within the northern portion of the study area, the dominantly nonuraniferous carbonate rock sequence, general absence of acidic volcanic units, and relatively minor exposure of granitic intrusives contribute to a generally negative uranium potential for this area. As a result, the entire area north and east of the Antelope Peak Caldera is considered to have low uranium potential with the exception of the southern half of Jake's Valley (T14-17N, R59-61E). The Tertiary rhyolites just north of this area and the granite stocks at Ruth (T16N, R61E) and in the Moorman Ridge areas (T15N, R59E) contribute clastic and arkosic sediments to Jake's Valley and are potential uranium source rocks for the southerly draining Jake's Valley ground-water regime (Spengler and others, 1979).

Between the Antelope Peak Caldera and Goldfield, the valley areas and some of the Toquima and southern San Antonio ranges are assigned speculative uranium potential (Drawing 14) which includes Little Fish Lake Valley. Many factors contribute to this speculative-potential uranium area. As can be seen on the geology and structure map (Drawing 5), large volumes of acidic ash flow tuffs and rhyolitic flows occur in the Monitor, Toquima, and Toiyabe Mountain ranges as do a number of large volcanic

caldera structures. In addition, a larger area of granitic and rhyolitic intrusive rock is exposed in the Toquima and San Antonio ranges than in any other portion of the northern valley study area, and the great majority of known occurrences are spatially associated with these intrusives and volcanics.

The northerly draining Monitor Valley and southerly draining Big Smoky and Montezuma valleys have received clastic, arkosic, and tuffaceous sediments from the above-mentioned ranges as well as leached and mobilized uranium derived from the abundant source rocks present in those ranges. Uranium occurrences in various members of the Siebert Tuff west of Tonopah are evidence that precipitating lithologies and environments are present in the Tertiary basin fill of Big Smoky Valley.

5.3.4 Nonmetallic and Industrial Minerals

The MX Additional Valley Study Area is experiencing a resurgence in exploration for nonmetallic and industrial minerals. As domestic and foreign demand increases for various commodities, areas like the study area with limited past production but favorable geologic environments become prime exploration targets.

5.3.4.1 Barite

Barite is economically the most important industrial mineral in the study area with two mines currently in production in the Northumberland District (Table 5-5). Numerous barite occurrences are known in the western half of the study area where transitional and western facies eugeosynclinal siliceous rocks of Paleozoic age were thrust eastward (Roberts Thrust) during

the Late Devonian Antler orogeny. The Nevada "Barite Belt" coincides with the Antler Orogenic Belt (Drawing 5), and the bedded barite deposits within this belt occur in the western facies cherty host rocks of Devonian and older age (Shawe and others, 1969; and Mitchell, 1980).

Environment

Barite occurs commercially as bedded deposits in siliceous sedimentary host rocks (Brobst, 1980) and commonly, but seldom commercially, as a secondary or gangue mineral associated with base- and precious-metal vein and replacement deposits. A controversy exists within the industry as to the origin of bedded barite deposits. Ketner (1963) describes them as epigenetic hydrothermal in origin; and Shawe and others (1969) cite evidence for the diagenetic replacement of the host rocks prior to lithification. The origin is obviously complex, and Bryan and Papke (1980) suggest that a combination of processes, both sedimentary and hydrothermal, may contribute to the formation of these deposits.

Occurrences, Distribution, and Production

Two mines are currently producing barite from stratiform deposits in East and West Northumberland canyons. Near the mouth of East Northumberland Canyon (T12N, R46E), All Minerals Corp. is operating an open-pit barite mine and milling facility in Devonian (Ordovician?) deposits discovered in 1969 (Photographs 17A, B). Production figures are not available for this mine, but the operation is expanding and All Minerals has staked

A VIEW N ALL MINERALS' BARITE MINE IN EAST NORTH UMBERLAND CANYON.

B VIEW W ALL MINERALS' BARITE PROCESSING FACILITY IN MONITOR VALLEY.

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PHOTOGRAPH 17	

additional mill site claims extending eastward from the present mill facility to Highway 82 (approximately 1.5 miles [2.5 km]) (Ertec Rocky Mountain, field examination, 1980).

Standard Slag Company is operating the second barite mine located on the south side of West Northumberland Canyon (T13N, R45E) just north of the study area boundary. This mine, known as the Old Soldier Mine (Photograph 18), produces nearly pure barite from a slightly smaller pit than the All Minerals Mine. Again, production figures are not available.

Other substantial deposits of bedded barite have been prospected in Wood Canyon (T13N, R46E) about 1 mile (1.6 km) north of East Northumberland Canyon and west of Big Smoky Valley at Summit Canyon (T13N, R42E) in the Toiyabe Range. Barite occurrences in veins are present in the Round Mountain, Manhattan, Eureka, and other mining districts; nodular barite has been reported in sediments near Morey Peak (T10N, R51E) (Kleinhampl, 1980; and Shawe and others, 1969).

Current Exploration Status

Recent expansion in oil and gas drilling in the U.S. and the attenuating need for drilling mud have substantially increased the demand for barite. Total domestic reserves are inadequate to meet projected demand through the year 2000 (see FN-TR-41 report Section 6.1). The result has been a resurgence in barite exploration in the western U.S. and principally in Nevada where 85 percent of U.S. production originates (Bryan and Papke, 1980).

VIEW NE – STANDARD SLAG'S OLD SOLDIER BARITE MINE
IN WEST NORTHUMBERLAND CANYON.

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PHOTOGRAPH 18

Current exploration is concentrated in the ranges and near-range pediments of the "Barite Belt" in central Nevada (see Antler Orogenic Belt, Drawing 5). Nearly all of the western facies lower Paleozoic rock units are potential hosts, but heaviest exploration effort is being centered on the Devonian-Ordovician units in the Toiyabe and Toquima ranges.

5.3.4.2 Gems and Semiprecious Stones

Turquoise is the only semiprecious stone with recorded production from the study area. Occurrences of turquoise are fairly common, but present production of gem-quality turquoise is from only three properties (Table 5-5). These mines are small and operate on an intermittent basis.

Kleinhampl (1980), Stewart and others (1977b), and USGS and others (1964) report turquoise occurrences in the following mining districts in or adjacent to (within 6 miles [10 km]) the study area:

Goldfield	(T23S, R42-43E)
Lone Mountain (Weepah)	(T2N, R40-41E)
Crow Springs	(T5-6N, R40E)
Klondyke	(T1N, R43E)
Easter Blue	(T7N, R39E)
Royston	(T6N, R39-40E)
Belmont	(T9N, R45E)
Manhattan	(T8N, R44E)
Indian Blue	(T15N, R46E)
Dry Creek	(T19N, R46-47E)

The largest recorded turquoise production has come from the Royal Blue Mine in the Royston District where over $5,000,000 in turquoise was mined prior to 1915 (Albers and Stewart, 1972). Production from other areas has been much smaller than this, and

COMPANY NAME	MINE	COMMODITY	MINING DISTRICT	SEC., T-R	OTHER INFORMATION
ESMERALDA COUNTY, NEVADA					
Earl Nesser[1]	Gemfield Mine	Semi-precious gemstone	Goldfield	Sec. 29, T2S, R42E	2 employees Open pit
Lone Mountain Turquoise Mining Co.[1]	Blue Jay Mine	Turquoise	Lone Mtn.-Weepah	Sec. 18, T1N, R41E	3 employees Open pit
LANDER COUNTY, NEVADA					
Bluestone Co.[1]	Bluestone Mine	Turquoise	Unorganized	Sec. 20, T20N, R47E	3 employees Open pit
NYE COUNTY, NEVADA					
All Minerals, Inc.[1]	Barite Mine & Mill	Barite	Northumberland	Sec. 9, T12N, R46E	28 employees Open pit & mill Photographs 17A, 17B
Standard Slag Co.[1]	Old Soldier Mine	Barite	Northumberland	Sec. 10, T13N, R45E	Photograph 18

[1]Nevada Industrial Commission, 1980, Directory of Nevada Mine Operations active during calendar year 1979 (and draft additions for 1980): Compiled by the staff of the State Inspector of Mines, Francis E. DuBois, III, State of Nevada.

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NONMETALLIC AND INDUSTRIAL MINERAL PRODUCING PROPERTIES IN THE STUDY AREA

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TABLE 5-6

future exploration and operations will likely continue to be small in scale.

5.3.4.3 Fluorspar

There has been limited past production of fluorspar reported from the Wall Mine, Manhattan Mining District, but there is no current production anywhere within the study area. Sizeable production of fluorspar has come from the Shoshone Range about 15 miles (25 km) west of the study area (Kleinhampl, 1980), and a large, low-grade deposit has been drilled in the Fish Creek District (T18N, R52E). Host rocks and geologic environments similar to these deposits are present in many areas of the study area, and commercial fluorspar discoveries are certainly possible within the study area.

Occurrences of fluorspar as a secondary or gangue mineral associated with hydrothermal metallic vein and replacement deposits are common throughout the western half of the study area, in the Eureka and White Pine Districts, and in the Egan Range.

5.3.4.4 Clays

There are no clay-producing properties with either current or recorded past production in the study area. Two kaolin-type deposits have been prospected in and immediately adjacent to the study area. A deposit of approximately 100,000 tons of halloysite has been identified at the Liberty Copper Pit west of Ely (T16N, R62E), but it may be too small and too far from existing markets to be commercial (Olson in USGS and others, 1964).

The second known clay deposit is the Tonopah Lambertucci deposit (T3N, R42E) which consists of thin-bedded clays in altered Tertiary tuffs. The clay is of limited lateral extent and total volume. Because of the low unit value of clays and the distance from the study area to any significant market, future production of clay is not likely to be significant. Locally, construction of the MX system could create a market for certain clays and result in commercial exploitation.

5.3.4.5 Pegmatite Minerals

Feldspar, beryl, and mica are the economically important pegmatite minerals in Nevada; however, no production from pegmatites is known in the study area. Since pegmatites are not common in the study area, no future exploration or production is anticipated.

5.3.4.6 Sulfur

No sulfur deposits are known to exist in the study area, and sulfur has not been recovered as a secondary product from sulfides or sour natural gas. About 1 mile (1.6 km) east of Tognoni Springs Mining District (T2-3S, R43E), an occurrence of native sulfur as irregular masses filling space in a shattered and bleached andesite has been investigated, but the deposit probably has no commercial value (USGS and others, 1964a).

5.3.4.7 Zeolites

No production of zeolite minerals is recorded from the study area, but occurrences are known at Goldfield (T2-3S, R42-43E), Tonopah (T2-3N, R42-43E) (Papke, 1972), and associated with

phosphatic minerals in the Manhattan District (Kleinhampl, 1980). Four significant zeolite occurrences northwest of the study area were investigated by Papke (1972). The environment of those occurrences is present in several valleys in the western portion of the study area (Basinski and Larson, 1979).

Natural zeolites, principally erionite and chabazite, occur in altered silicic ash-fall tuffs that were deposited in saline, alkaline lakes in west-central Nevada. Extreme devitrification of these tuffs is typical in areas of zeolite formation. Zeolites may also occur in devitrified rhyolitic pyroclastic units (Papke, 1972). This environment is present in most of Big Smoky, Monitor, Little Fish Lake, and Montezuma valleys. As the market for natural zeolites expands, these valleys are likely to experience increased exploration for zeolite deposits.

5.3.4.8 Other Epigenetic Nonmetallic Minerals

Commercial deposits of talc, refractory minerals, vermiculite, asbestos, and alunite have not been identified in the study area.

5.3.4.9 Diatomite

There are numerous diatomite occurrences in the western part of the study area, and extensive deposits with significant production lie just west of the study area in Nye County. Known occurrences in western Big Smoky Valley and on the south side of Lone Mountain (T20N, R1E) have been prospected, but there is no known production.

Practically all of the world's known diatomite deposits are located in California and Nevada (Olson in Ridge, 1979). Nevada's deposits are composed of microscopic skeletal remains of freshwater planktonic diatoms of late Tertiary age, while the more extensive California deposits are thicker marine diatom accumulations. Increases in demand for diatomite will result in increased exploitation of deposits in both environments.

5.3.4.10 Dimension Stone, Silica, Crushing Stone

Abundant deposits of various lithologies suitable for dimension stone use are present within the study area, but due primarily to the distance to market, these deposits have not been exploited and probably will not be developed to any large extent in the next 20- to 30-year period.

Silica is also fairly common in deposits of chert, jasperoid, sandstone, and quartzite within the study area, but there has been little past production. The Ordovician Eureka Quartzite has been mined for high purity silica outside of the study area. Outcrops of this unit with potential for silica exploitation have been mapped by Ketner (1976) and are shown in Drawing 13. Those in proximity to a railroad have good potential for development in the next 20 years should a market develop (Drawing 13).

Dolomite and limestone of sufficient purity to be used in cement is abundant in the eastern portion of the study area generally east of the Antler Orogenic Belt. No commercial development of

these resources has taken place within the study area largely due to the sparse population and distance to other markets. Deployment of the MX system in the area would undoubtedly lead to development of these crushing stone resources as well as local sand and gravel resources.

5.3.4.11 Perlite, Pumice, Pumicite

There has been no production of these light aggregate materials from the study area. Nevertheless, as with crushing stone, deployment of the MX system would expand the market for these materials, making development of some of the known deposits likely.

5.3.4.12 Phosphate

There has been no commercial development of any of the phosphate occurrences in the study area. Phosphatic rocks occur in many units of the Lower Paleozoic section in the ranges of the study area. Most occurrences are local, thin-bedded inclusions of phosphate nodules in siltstone and limestone with grades of three percent to six percent phosphate (Rogers and others, 1970). Additional phosphatic rocks, with grades of six percent to 11 percent P_2O_5, have been identified (Cohenour, 1980) in thin-bedded Tertiary lake sediments west of Tonopah. None of these known deposits are currently economic, and they are not likely to be economically recoverable in the next 20- to 30-year period.

5.3.4.13 Salines, Brines

The Foote Mineral Company's lithium carbonate operation in Clayton Valley produces an estimated $16 million in lithium annually (1978 estimated production) from brine solutions in Clayton Valley (Bryan and Papke, 1980). This deposit lies approximately 7 miles (11 km) southwest of the study area, and the environment of the deposit extends north and east into the study area in Montezuma and Big Smoky valleys.

Bohannon and Meir (1976) conducted a regional geochemical sampling program for lithium in an attempt to identify other basins in Nevada similar to Clayton Valley. Their results were indeterminant, partially due to sampling methods, but anomalous values of 640 parts per million (ppm) lithium in Montezuma Valley (T15N, R14E) and 120 ppm in northern Big Smoky Valley (T13N, R43E) were reported. Other playa deposits with potential for sodium, boron, potassium, and lithium salt occurrences are present in Jake's Valley (T16N, R60E) and Monitor Valley (T13,N, R47E). Future exploration for evaporative deposits in these areas is likely. The intensity of exploration and grade of producible deposits will be a function of the market demand and price of these commodities.

Although there has been no anhydrite or gypsum production from the study area, Standard Oil Company's Summit Springs No. 1 well (Sec. 32, T20N, R60E) encountered nearly 5000 feet (1515 m) of Permian sediments between 1389 and 6639 feet (420 and 2023 m) containing beds of anhydrite up to 100 feet (30 m) thick and

gypsum up to 8 feet (2.5 m) thick. The areal extent of these deposits has not been explored (Hose and others, 1976).

5.3.4.14 Other Syngenetic Nonmetallic and Industrial Minerals

Commercial deposits of borates and potash are not known to occur in the study area. Exploration in the intermontane valleys may locate deposits of commercial interest in the future.

5.3.4.15 Basin-Fill Aggregate

Occurrences, Distribution, and Production

Potential aggregate sources within the study area generally occur as either Quaternary alluvial and coarse-grained lakebed deposits or as Precambiran to Tertiary rock that can be used as a crushed-rock aggregate source. The latter pre-Quaternary rock deposits are generally comprised of limestone, dolomite, quartzite, intrusive, and volcanic rocks. These, in turn, provide the source materials for sand and gravel formed by natural processes that weather and transport these materials to sites of deposition. The coarse deposits generally occur along the flanks of the mountain ranges, whereas, the finer sediments generally occur further from the source area. In general, the size of these sand and gravel deposits is dependent upon the size of the drainage basin, slope, climate and composition, and structure of the rocks in the study area. The extent of the rock deposits is dependent upon the type and nature of the deposit and any structural controls that were imposed either before, during, or after deposition.

Suitable sand and gravel deposits are widely distributed throughout the Additional Valley Study Area. The sand and gravel deposits commonly form the alluvial fans along the margins of the mountain ranges as well as coarse-grained lakebed and gravel bar deposits in the broad valleys. The rock deposits are generally found associated with the mountain ranges themselves, but their quality is variable. By far, the majority of all known pits or sites from which aggregate materials have been or are currently being extracted are generally in close proximity to existing roads and highways. Sites of sand and gravel, as well as the rock deposit areas, must be near the construction sites because of low-unit value of material does not permit the cost of long transportation. As a result, many sites have been located near those areas of maximum usage, that is, the larger urban areas. Possible exceptions to this occur during highway construction where large quantities of suitable aggregate materials are needed but not necessarily located near a currently operating pit.

Current Exploration Status

Recently, the only significant exploration for suitable aggregate sources has been limited to the state highway departments and a few private corporations. The Bureau of Land Management, the agency responsible for administering the use of public lands, has the responsibility for issuing permits and keeping records of the past and present requests for aggregate removal.

Review of Potential

In general, voluminous aggregate resources are present within the Additional Valley Study Area. This evaluation is based on the distribution of potential aggregate sources as delineated by the geologic map (Drawing 15) and classified for usage in Chart 2. A detailed discussion of the classification system is presented in the regional MX Mineral Resources Survey (FN-TR-41). These resources tend to be widely distributed and should be adequate to supply all foreseeable future needs for highway and urban requirements.

Generally the best quality sand and gravel deposits are the alluvial and coarse-grained lakebed deposits of Quaternary age. The remainder of the potential aggregate sources are those classified as rock. These rock deposits are made suitable as aggregate material after crushing or other beneficiation. Most rock deposits in the study area range from suitable to marginally suitable as crushed-rock materials. The highest quality rocks are generally intrusives (mainly granodiorite to quartz-monzonite in composition) and dolomite which are chert free. Limestones and quartzite are less suitable. Considered even less suitable (marginal) are basalts and other volcanic rocks.

5.4 ENERGY-RELATED RESOURCES

Oil and gas, oil shale, coal and lignite, and geothermal resources are grouped in this section. No commercial grade oil shale is known within the study area, and a discussion of the low-grade occurrences and possible future producing units is

presented in Section 5.4.3 of the Regional Mineral Survey (FN-TR-41). The coal occurrence at Pancake Summit (T18N, R56E) in the study area is also discussed in the FN-TR-41 report (Section 5.4.4) and is not repeated here. No other coal occurrences are known in the study area.

5.4.1 Oil and Gas

An in-depth discussion of the oil and gas occurrence and the favorable source and host units of the study area is presented in Section 5.4.1 of the Regional Mineral Survey (FN-TR-41). To summarize that discussion, the most favorable source beds in the study area are the carboniferous black shales of the Mississippian Chainman Shale and Diamond Peak formations. Significant source potential is also attributed to the carbonaceous strata of the Tertiary Sheep Pass Formation.

Host units in the study area with the best potential for oil and gas reservoir development are the Mississippian Diamond Peak-Illipah Formation (porous sand facies) and the Tertiary Sheep Pass Formation. High potential was assigned to those areas where both the Diamond Peak-Illipah and Sheep Pass formations overlie the Chainman Shale. Good potential was assigned to those areas where either the Diamond Peak-Illipah or the Sheep Pass Formations overlie the Chainman Shale but are not superposed.

The area of deposition of the porous sand facies of the Diamond Peak-Illipah Formation, where that unit overlays the Chainman Shale, is shown as the "Mississippian Limit" in Drawing 15. The

area of deposition of the Tertiary Sheep Pass Formation is shown as the "Tertiary Limit" in Drawing 15, and within this area, a good potential for oil and gas has been assigned. This good potential increases to high where the Sheep Pass Formation overlies the Diamond Peak-Illipah Formation.

Twenty-four wells have been drilled for oil and gas in or immediately adjacent to the study area as of March 1980. Of this total, 20 are within the study area and all are in White Pine County. Only one well, Gulf Oil's Newark Valley Unit No. 1 (Sec. 11, T19N, R55E), falls outside of the Mississippian favorability zone shown in Drawing 15.

The criteria for defining favorability and potential are the same as that described in Section 5.4.1 of the FN-TR-41 report. It is noted, however, that in several of the wells drilled in the high-potential area shown in Drawing 15, the Tertiary section thought to have been deposited in this area has been removed by erosion.

There are shows of gas and oil in Mississippian strata in cuttings from 10 of the wells (Table 5-6), but no production has been attained from any well in the study area. Exploration for oil in White Pine County is continuing, and recent interest has been shown in Kobeh Valley in central Eureka County (Butte Resources Co., written communication, 1980).

Three test wells drilled by the Atomic Energy Commission (AEC) in the 1950s are located within the study area (Drawing 15), but

MAP NO.	WELL	DATE DRILLED	LOCATION	OPERATOR	T.D.	OIL SHOW	GAS SHOW
1	Newark Valley Unit No. 1	1966	Sec. 11, T19N, R55E	Gulf Oil Corp.	5001		
2	Meridian Unit No. 1	1950	Sec. 31, T16N, R56E	Standard-Conoco	10,314	X	X
3	Nevada-Federal No. 1	1961	Sec. 5, T15N, R57E	Suntide Petroleum Co.	2681		
4	?	1978	Sec. 10, T19N, R57E	Tannehill Oil Co.	677		
5	Nevada-Federal No. A1	1964	Sec. 23, T18N, R57E	Suntide Petroleum Inc.	7980		
6	Illipah-Federal No. 1	1967	Sec. 21, T18N, R58E	Tenneco Oil Co.	7620		
7	G.B. Core Hole No. 6	1970	Sec. 32, T18N, R58E	Tenneco Oil Co.	920		
8	Illipah Anticline No. 1-2	1920	Sec. 11, T17N, R58E	Illipah Petroleum	929 1572	X X	
	Illipah Anticline	1979		Northwest Expl. Co.	7154	X	
9	Long Valley No. 1	1974	Sec. 35, T23N, R58E	Guadalupe Expl. Corp.	7020	X	X
	?	1967		El Paso Nat. Gas	7061	X	X
10	?	1978	Sec. 34, T22N, R58E	American Quasar	6562		

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WELLS DRILLED FOR OIL AND GAS IN THE STUDY AREA
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TABLE 8-6

MAP NO.	WELL	DATE DRILLED	LOCATION	OPERATOR	T.D.	OIL SHOW	GAS SHOW
11	G.B. Core Hole No. 2	1970	Sec. 33, T22N, R59E	Tenneco Oil Co.	365		
12	Robber's Roost No. 28-76	1967	Sec. 28, T20N, R59E	Harry Riggs	6428		
13	Summit Springs Unit No. 1	1951	Sec. 32, T20N, R60E	Standard-Conoco	11,543	X	X
14	Hayden Creek Unit No. 1	1950	Sec. 17, T15N, R59E	Standard-Conoco	5117	X	X
15	?	1977	Sec. 1, T14N, R60E	Pyramid	1660		
16	?	1978	Sec. 1, T14N, R60E	Northwest Expl. Co.	4410		
17	Jake's Wash Unit 2A	1975	Sec. 14, T14N, R60E	Texas American Oil Corp.	3742		
18	Jake's Wash Unit 1 & 4	1975	Sec. 4, T14N, R61E Sec. 9, T14N, R61E	W. Witter Gulf Oil Corp.	2603 4600	X X	
19	G.B. Core Hole No. 3	1970	Sec. 25, T21N, R60E	Tenneco Oil Co.	956		
20	Nevada-Federal "B5" No. 1	1965	Sec. 14, T20N, R61E	Gulf Oil Corp.	2978		
21	G.B. Core Hole No. 4	1970	Sec. 16, T19N, R61E	Tenneco Oil Co.	712		

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WELLS DRILLED FOR OIL AND GAS IN THE STUDY AREA
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TABLE 9-6

no information on possible oil or gas shows in these wells was found. No other oil and gas wells have been drilled outside of White Pine County that lie within the study area.

5.4.2 Geothermal

Geothermal energy is derived from the natural heat of the earth's crust. Within the study area, geothermal energy is generally contained within localized hydrothermal convection systems of low to intermediate temperature. This natural energy is economically significant, however, only when concentrated into restricted volumes in a manner analogous to the concentration of ore deposits or commercial petroleum reservoirs. Further discussion concerning geothermal energy in general, along with any pertinent definitions, may be obtained by referencing Section 5.4.2 of the Mineral Resources Survey (FN-TR-41). This section on geothermal resources considers low (194°F [<90°C]) to intermediate (194°F to 302°F [90°C to 150°C]) temperature hydrothermal convection systems as defined by Muffler (1979). Locally, within KGRAs (Known Geothermal Resource Areas), high temperature resources may also occur.

The following sections include discussions on the occurrences of geothermal resources in Nevada with an emphasis on the MX study area. Additional discussions summarize the status of geothermal exploration and development, the geologic factors for identifying the areas of geothermal occurrence, and the geothermal potential of favorable areas (within the study area).

5.4.2.1 Occurrences

The occurrences of thermal water within the study area are plotted in Drawing 16 and listed in Appendix B. These compilations include 48 occurrences of thermal waters for which 30 have reported surface temperatures above 82.4°F (28°C). The remaining 18 springs and wells either have temperatures below 82.4°F (28°C) or have no numerical temperature value assigned; temperatures are described as warm, hot, or boiling (?) while seven springs lack temperature data altogether. The overall range of recorded temperatures for thermal waters in the study area is 71°F (21.7°C) to 400°F (204.4°C). The sources of the thermal waters include both springs and wells and thermal waters encountered in mine workings.

In addition to the thermal wells and springs, there is one KGRA located in the west-central portion of the study area. This KGRA is known as the Darroughs Hot Spring KGRA (Drawing 16) and covers approximately 13 mi^2 (33 km^2). Eleven thermal springs and wells are identified within this KGRA with surface temperatures of 180°F (82.2°C) to 400°F (204.4°C).

5.4.2.2 Exploration and Development

Considerable geothermal exploration and development are currently underway in Nevada. Exploration for geothermal resources suitable for the application in electrical generation is currently underway in Dixie Valley, Steamboat, and Beowawe, Nevada.

In addition, several commercial direct-head applications have been developed in Reno, Golconda, Caliente, Steamboat, Carson

City, Gabbs, Wabuska Hot Springs, and Fernley, Nevada. In design or evaluation stages are hot water systems for both Las Vegas and Reno. Further, geothermal leasing is taking place throughout Nevada with some of the leases being established within the MX deployment area (Drawing 17).

The Department of Energy State Coupled and Industry Coupled geothermal reservoir assessment programs are currently in progress (Foley and others, 1980; and Fiora, 1980). The industry-coupled program has 14 "work areas" in which geothermal reservoir assessments are in progress. Most of these work areas are in northwestern Nevada and southwestern Utah. None, however, are within the study area.

5.4.2.3 Geologic Environment

Thermal springs and wells are often surface manifestations of large geothermal reservoirs at relatively shallow depth. To define the limits of potential reservoirs, further data on the geologic environment which controls their occurrences need to be analyzed. However, the data are presently not available to delineate the resources within the study area. Therefore, the approach followed in this report is to compile and interpret existing geologic favorability criteria that are believed to govern or reflect the occurrence of geothermal reservoirs. The following geologic favorability criteria are generally accepted by workers in the field of geothermal resource assessment as useful evaluation tools. These are:

- o Hot springs;
- o Lineaments;

- o Late Tertiary and Quaternary fault distribution;
- o Margins of volcanic centers; and
- o Aeromagnetic data.

In the remainder of this section, these criteria are described in terms of geologic factors specific to the study area. Individually, they may not be significant to this study, however, when considered together, they serve to establish a basis for identifying potential areas of geothermal favorability.

Numerous hot springs and wells are scattered throughout the study area with a majority being located in the west-central portion (Drawing 16). The occurrence of hot springs (or wells) presents tangible evidence of a potential geothermal reservoir at generally shallow depths <2 miles (<3 km). Therefore, the presence (or absence) of hot springs is an important consideration in assessing the geothermal potential. Little Fish Lake Valley is such an example of hot springs and wells depicting an area of geothermal potential. It should be noted, however, that the absence of hot springs in itself does not necessarily exclude geothermal potential. A geothermal reservoir could exist at depth but lacks the proper geologic conditions needed to produce such a surface manifestation.

Three major east-west lineament systems cross the southern and western portions of the study area. These are, from north to south, the Pritchard Station, Pancake Range, and Warm Springs lineaments. In addition, there are several northwest-southeast and northeast-southwest trending lineaments located throughout the study area. These lineaments are based on data from Ekren

and others (1976) and this report. Lineaments are considered important in that they generally coincide with hot springs and the volcanic centers (Drawing 16). Lineament data in itself do not infer or preclude geothermal favorability. Rather, these are used to help delineate geologic structures that may or may not favor a geothermal environment.

Late Tertiary and Quaternary fault distribution is an important criterion for the evaluation of geothermal potential. These structures may provide pathways which allow for the deep circulation of meteoric waters to zones of higher than normal geothermal gradient. Another possibility is that these faults may provide the pathways by which magma can migrate to near-surface depths. In addition, these faults or fault zones may provide for the "plumbing" within the geothermal reservoir, thereby allowing for the heating and circulation of these waters. The central portion of Monitor Valley may be an example of faults providing both heat access and circulation within a geothermal reservoir as evidenced by the numerous hot springs present.

The mutual intersections of Late Tertiary and Quaternary faults, lineaments, and the margins of volcanic centers are significant in that they facilitate heat transfer to ignimbrite aquifers as evidenced by localization of hot springs. North Big Smoky Valley is an example of such a mutual intersection (Drawing 16).

Aeromagnetic data, as with lineament data, do not affirm or exclude areas of geothermal potential. These data, however, are used to delineate geologic structures that may or may not favor

a geothermal environment. For example, aeromagnetic data may indicate regions where the basement rock has been uplifted along normal faults. Aeromagnetic data by Zietz and others (1978) suggest the presence of basaltic intrusions, possibly along pre-existing caldera ring faults. These young basalts, where of sufficient magma chamber volume, could have locally reheated ignimbrite aquifers. The number of possible geothermal reservoirs within the study area produced by reheating from these young volcanic systems is not known.

It should be noted that deep-seated structures, as indicated by lineaments and aeromagnetic data, are an important consideration in determining areas of geothermal potential. As mentioned earlier, the rationale for this is based upon the assumption that these structures allow for either the deep circulation of meteoric waters or for the near-surface migration of magma. Therefore, a strip of a few miles (± 1.2 mi [± 2 km]) on both sides of these structures was used to delineate a zone that is affected by these structures. These zones were used in the evaluation and delineation of areas of geothermal potential.

Other considerations that may be of importance in assessing areas of geothermal potential, but not used in this evaluation, are low Richter magnitude (<M = 4) earthquakes and proximity to young silicic volcanic centers. Low Richter magnitude earthquakes are generally considered important since they may indicate movement of geothermal waters within the reservoir such as the natural injection of geothermal fluids along a fault (Ward,

Ross, and Nielson, 1981). However, these data were not available on low-magnitude earthquakes for the study area and, therefore, were not considered in assessing the geothermal potential within the area.

Proximity to young silicic volcanic centers can also be an important consideration is assessing areas of geothermal potential since silicic volcanic rocks retain heat over a longer time interval. However, location and determination of silicic volcanic centers were not readily accomplishable with the data available. Therefore, no reliable correlations between silicic volcanic centers and occurrences of geothermal activity could be made.

The criteria discussed above were used to establish favorability areas for geothermal potential discussed in the following section.

5.4.2.4 Review of Potential

These areas with high favorability for occurrence of low-to intermediate-temperature geothermal resources are delineated in Drawing 16 are listed below (most favorable listed first):

1. Big Smoky Valley, north;
2. Monitor Valley, central;
3. Monitor Valley, north;
4. Antelope Valley;
5. Big Smoky Valley, south;
6. Butte Valley, north;
7. Little Fish Lake Valley;
8. Butte Valley, south; and
9. White River Valley.

Exclusive of the above areas of favorability, nine thermal springs, wells, or mine workings occur in widely scattered

localities within the study area (Drawing 16). These may be located by referring to Appendix B with map reference numbers 2, 4, 6, 8, 9, 10, and 11. In the vicinity of these thermal sites, the geothermal potential is considered good to speculative. All other areas are considered to have low potential for the occurrence of geothermal resources.

6.0 LAND STATUS

Land status described in this section relates to mining and energy-resource activity only. This section summarizes the status of claims (patented and unpatented), leases (state and federal), and permits (sand and gravel) in the MX deployment areas.

Data sources were county and state public records, Nevada Bureau of Mines and Geology, Nevada State Inspector of Mines, universities, U.S. Bureau of Land Management, U.S. Geological Survey, and private mineral industries.

6.1 LAND STATUS CLASSIFICATION

U.S. Bureau of Land Management commonly utilizes three categories of land status for mineral resources surveys. These categories are public lands, state lands, and private lands. Within these three categories, there are six classifications of resource ownerships which have been used in this study:

1. Public Lands
   - o Federal oil, gas, and geothermal leases; and
   - o Unpatented mining claims;
2. State Lands
   - o State mineral, oil and gas leases;
3. Private Lands
   - o Patented mining claims; and
   - o Nonfederal fee land.

Also considered in this study are sand and gravel permits issued by the Bureau of Land Management.

Two sets of maps, 1:250,000 scale, are included which show the location of five of the classifications, Drawing 17 for leases and Drawing 18 for claims. Because of drawing scale, locations are illustrated to the nearest full section; a section may hold up to 32 full-size claims. Sand and gravel permit locations have not been plotted on maps for this study.

A tabulation of claim and lease recordings is presented in Appendix A. The appendix is further divided into patented claims, unpatented claims, federal lease, nonfederal fee land, and state mineral lease. Individual records are organized by valley, range, township, and section. The description of each claim or lease includes the owner name and address and the acreage involved.

Sand and gravel permit information is listed in Appendix C. These listings are divided into four classifications of permits as identified in BLM records. These classifications are: Material Site Right-of-Way, Free Use Permit, Community Pit, and Mineral Sale Site. Sand and gravel source areas are described in Appendix C by permit classification, location, and quantity or acreage.

A summary of the land status tabulations presented in Appendix A and C is given as follows:

Category	No. Claims/Interest	Acreage
Federal Leases		
Oil and Gas	626	798,415
Geothermal	13	16,236
Oil Shale	0	0
Coal and Lignite	0	0

Category	No. Claims/Interest	Acreage
Potash	2	800
Phosphate	0	0
Sodium	0	0
State Mineral Leases	0	0
Nonfederal Fee Land	62	23,242
Patented Mining Claims	329	6,534
Unpatented Mining Claims		
Lode	4,497	75,233
Placer	347	16,879
Millsite	1,238	5,004
Sand and Gravel	42	1,945+

6.2 LEASES

6.2.1 Federal and State Leases

Federal mineral leases comprise only six interests for a total of 2460 acres. These are confined to Jakes and Big Smoky valleys. Of the six individual leases, two are for potash and the others are special land use permits. Big Smoky has four of the six leases containing 2080 acres. Both mineral leases are in Big Smoky.

The special land use permits in Big Smoky Valley cover two large-sized sand dunes.

There are no state mineral leases in the seven additional valleys.

6.2.2 Oil and Gas Leases

Oil and gas leases in the seven valleys total 798,415 acres in 626 leases. The oil and gas leases cover practically all of the available acreage in all of the valleys except for the southern quarter of Monitor Valley and Big Smoky Valley which has only three leases totaling 4066 acres.

6.2.3 Geothermal Leases

One of the major hot springs in Nevada, Darrough Hot Springs, is just north of the northern end of Big Smoky Valley siting area. The USGS has designated a KGRA around the spring. Surrounding the KGRA are noncompetitive geothermal leases, of which 13, totaling 16,236 acres, are within the siting valley.

6.2.4 Oil Shale

There are no oil shale leases in the study area.

6.2.5 Coal or Lignite

There are no coal or lignite leasing activities in the seven valley study area.

6.2.6 Potash

There are only two federal potash leases, both in Big Smoky Valley, and together they comprise 800 acres. The leases are situated along the western fringe of the valley in the area of rather intense mineral activity.

6.2.7 Phosphate

There are no phosphate leases in the study area.

6.2.8 Sodium

There are no leases for sodium minerals within the area.

6.2.9 Nonfederal Fee Land

This category comprises a very small portion only of the total deployment area. Total acreage is 23,242 of which 91 percent or 21,162 acres are in two of the seven valleys. One valley has no fee land.

A tabulation of fee land by valley is given:

VALLEY	ACREAGE
Butte	280
Kobeh	640
Jakes	800
Long	none
Newark	360
Monitor	10,323
Big Smoky	10,839

Location of these lands follows no particular pattern within the individual valleys. Parcel locations range from valley border to valley centers.

6.3 PATENTED MINING CLAIMS

Big Smoky Valley dominates this land-status category with 274 claims or 87 percent of a total of 327 in all seven valleys. Only three others, Butte (20), Monitor (34), and Kobeh (1) are sites of patented mining claims. The 327 claims comprise 6534 acres and are owned by 78 individual interests.

Only a few patented mining claims are of recent origin. Most patented claims represent past mineral interest. Because this past activity was confined mainly to the highlands, all patented mining claims within the deployment area are found along valley edges. With the exception of two larger holdings of 19 and 50 claims each and one of 12 claims, the other patented holdings are mostly single claims.

The 19 claim groups owned by Anaconda form the core of the only active mine in which patented claims are involved. All other claims represent mineral areas with unknown to high interest.

6.4 UNPATENTED MINING CLAIMS AND MILL SITES

Unpatented mining claims are identified from BLM microfiche dated 24 January 1981 and county records as of 27 March 1981.

Of the seven valleys, Big Smoky has the vast majority of claiming activity. There are 6082 unpatented mining claims and mill sites in the total deployment area. Of these, 79 percent, or 4798 claims, are in Big Smoky alone. A tabulation of total claims is given:

	CLAIMS	ACREAGE
Lode	4498	75,233
Placer	347	16,879
Mill Site	1238	5,004

6.5 SAND AND GRAVEL PITS

There is no shortage of sand and gravel in Nevada. Every valley contains vast quantities. The quality, however, varies widely.

Because the valley sediments are made up primarily of alluvial slopes grading into alluvial plains rather than fluvial river deposits, the proportions of sand to gravel are not always ideal material sales sites and community pit. As would be expected, these permits generally are adjacent or near to road and highways. Big Smoky again leads all other valleys in number of permits. From a total of 42 permits in the overall deployment area, 19 permits are in Big Smoky. A tabulation by categories is given as follows:

VALLEY	MATERIAL SITE	FREE-USE PERMIT	MATERIAL SALES SITE	COMMUNITY PIT
Butte	0	0	0	0
Kobeh	0	0	0	0
Jakes	3	4	0	0

VALLEY	MATERIAL SITE	FREE-USE PERMIT	MATERIAL SALES SITE	COMMUNITY PIT
Long	2	4	0	0
Newark	1	3	0	0
Monitor	6	0	0	0
Big Smoky	18	1	0	0
	30	12	0	0

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